

NTIS HC \$18.50

RESULTS OF A SPACE SHUTTLE
PLUME IMPINGEMENT
INVESTIGATION
AT STAGE SEPARATION
THE NASA-MSFC IMPULSE
BASE FLOW FACILITY

July 1972

(NASA-CR-124000) RESULTS OF A SPACE
SHUTTLE PLUME IMPINGEMENT INVESTIGATION AT
STAGE SEPARATION IN THE NASA-MSFC IMPULSE
BASE FLOW FACILITY (Lockheed Missiles and
Space Co.) 323 p HC \$18.50 CSCL 20X

X73-155-9

G3/32 16°19' Unclassified

PRECEDING PAGES BLANK NOT FILMED

FOREWORD

The research described in this report was conducted by the Lockheed-Huntsville Research & Engineering Center for the Aero-Astroynamics Laboratory of Marshall Space Flight Center (MSFC), Contract NAS8-26801. The study was performed at the request of Mr. C. Dale Andrews, S&E-AERO-AAE.

The authors are grateful to Mr. Hal Gwin, S&E-AERO-AEG, who was most helpful in his efforts to assure that the required hardware and equipment were available as needed. Thanks are also due Mr. John H. Porter, Northrop Services, Inc., for his supervision of the tests and his critical analysis of the test results in reduced form prior to their receipt by the authors.

PRECEDING PAGE BLANK NOT FILMED

CONTENTS

Section	Page
FOREWORD	ii
SUMMARY	iv
NOMENCLATURE	v
1 INTRODUCTION	1-1
2 EXPERIMENTAL PROGRAM	2-1
2.1 Facility Description	2-1
2.2 Test Technique	2-1
2.3 Instrumentation	2-2
2.4 Models	2-3
2.5 Motor/Booster Relative Test Positions	2-8
2.6 Data Tabulation	2-8
2.7 Data Accuracy and Repeatability	2-9
2.8 Alignment Accuracies	2-10
3 EXPERIMENTAL RESULTS	3-1
3.1 Plume Impact Pressure Surveys	3-2
3.2 Booster Impingement Data	3-2
3.3 Data Analysis/Reduction	3-2
4 CONCLUSIONS	4-1
5 REFERENCES	5-1
Appendices	
A Tables	A-1
B Figures	B-1

PRECEDING PAGE BLANK NOT FILMED

SUMMARY

Results are presented for an experimental space shuttle stage separation plume impingement program conducted in the NASA-Marshall Space Flight Center's Impulse Base Flow Facility (IBFF). Major objectives of the investigation were to:

1. Determine the degree of dual engine exhaust plume simulation obtained using the equivalent engine;
2. Determine the applicability of the analytical techniques; and
3. Obtain data applicable for use in full-scale studies.

The IBFF tests determined the orbiter rocket motor plume impingement loads, both pressure and heating, on a 3% General Dynamics B-15B booster configuration in a quiescent environment simulating a nominal staging altitude of 73.2 km (240,000 ft). The data included plume surveys of two 3% scale orbiter nozzles, and a 4.242% scaled "equivalent" nozzle - equivalent in the sense that it was designed to have the same nozzle-throat-to-area ratio as the two 3% nozzles and, within the tolerances assigned for machining the hardware, this was accomplished.

The IBFF is a short-duration test facility utilizing scaled versions of hot-flow rocket motors. Combustion chamber temperatures are full-scale values while the operating pressures may or may not match full-scale values. The combustion products and resulting species are equivalent to prototype values.

PRECEDING PAGE BLANK NOT FILMED

NOMENCLATURE

Symbols

A^*	throat cross-sectional area, cm^2 (in. ²)
A/A^*	expansion ratio
D_{equiv}	equivalent nozzle exit plane diameter, cm (in)
H_2	hydrogen charge tube or gaseous hydrogen
H_T	total pressure probe in hydrogen charge tube
\dot{m}	mass flow, gm/sec (lb/sec)
O_2	oxygen charge tube or gaseous oxygen
O_T	total pressure probe in oxygen charge tube
P_o , P_c	combustion chamber pressure, N/cm^2 (lb/in. ²)
P_o^*	pitot total pressure, N/cm^2 (lb/in. ²)
P_x , P_{imp}	local measured pressure on impingement model, N/cm^2 (lb/in. ²)
P_{N_1}	static pressure tap approximately 0.48 cm from exit plane of nozzle
q	heating rate, watts/ m^2 (Btu/ ft^2 -sec)
R	radial distance, cm (in.)
r^*	throat radius, cm (in.)
X	axial distance downstream of nozzle exit plane, cm (in.)
Y	radial distance from nozzle centerline, cm (in.)
Z	radial distance from nozzle centerline, cm (in.)

Greek

α	angle of incidence of orbiter engine centerline relative to top centerline of booster, deg
----------	---

Greek

θ impact probe angle, deg

ψ see Fig. 7

Subscripts

j plume jet

∞ freestream

Section 1
INTRODUCTION

The analysis of nozzle flows and the expanding plume has been the subject of many analytical and experimental programs in the past. The state of the art in analytical and empirical plume definition has progressed significantly in the past few years, in particular the capability to predict the impingement effects on a body immersed in the plume flow field (Refs. 1 through 12).

The gasdynamic analysis of the plume and the appropriate scaling parameters for proper plume simulation have been the subject of most of these studies. Reference 12 provides a complete set of usable data for a plume impingement study in the form of nozzle analysis, plume definition and plume impingement on impact probes, a flat plate and quarter-cylinder. Both analytical and experimental results are presented.

The major problems associated with plume impingement in relation to recent space flight tasks have concentrated on the plume expansion and the resultant loads from typical attitude control and auxiliary propulsion systems. With the concepts as envisioned for the space shuttle program the exposed surfaces subjected to impingement loading resulting from stage separation and the ensuing orbiter engine burn create some possible control problems (see, e.g., Refs. 13 and 14).

The capability does not exist (within presently known techniques) to analyze a multiplume flow field such as that which will be found on the space shuttle orbiter vehicle without resorting to extremely cumbersome and time-consuming techniques. The interactions between the individual nozzle plumes cannot be defined analytically, and no empirical techniques are known to exist.

A technique was used, as reported in Ref. 15, to predict impingement loading on a shuttle vehicle by predicting the loads that result from a single nozzle. The method is termed the "effective" or "equivalent" plume analytical technique. This technique can, for more than five nozzle diameters downstream of the exit plane, effectively simulate the corresponding analytical plume periphery shape of a shuttle orbiter engine assembly. Prior to this test there was a lack of experimental data to which results obtained by this technique could be directly compared. This was therefore one of the basic purposes in utilizing both the equivalent nozzle and the dual nozzle assembly. A secondary purpose for using the single equivalent nozzle was to check out the operational characteristics of the hardware.

The purpose of this report is to present the results of an experimental program based on this technique and the comparisons of pressures and heating rates based on the model motor operating conditions.

The plume local flow properties are computed using theoretical flow-field results obtained from the Lockheed Method-of-Characteristics Computer Program (Ref. 16) which have been stored previously on magnetic tape. Real gas equilibrium or frozen thermochemical data are obtained from the computer programs of Refs. 17 and 18, respectively. Effects which can be included in the plume calculations are: (1) treatment of shock waves; (2) fuel striations; (3) nozzle effects; (4) nozzle boundary layer; and (5) plume external flow conditions. The stagnation point heat transfer theory used in calculating the heating rate indicator is that of Fay and Riddell (Ref. 19). Reference 20 contains detailed results of this technique.

Section 2

EXPERIMENTAL PROGRAM

2.1 FACILITY DESCRIPTION

The Impulse Base Flow Facility (IBFF) consists of a vacuum tank, vacuum pumping system, nozzle model with supply tubes, gas handling system and required instrumentation. Figure 1 is a schematic of the facility layout. References 21 and 22 present detailed information on the facility and its operating characteristics.

The environmental chamber is a mild steel tank, 5.5 m (18 ft) in diameter and 7.9 m (26 ft) long. The chamber can be evacuated to 5.0×10^{-4} torr for altitude simulations in excess of 91 km (300,000 ft). The chamber is evacuated in three steps:

- Equalize the chamber pressure with a 1189 m^3 ($42,000 \text{ ft}^3$) vacuum sphere to 0.2 N/cm^2 (15mm Hg);
- Evacuate the chamber to $6 \times 10^{-4} \text{ N/cm}^2$ (50 microns Hg) with mechanical pump and blower booster; and
- Further evacuate by diffusion pump to $0.6 \times 10^{-5} \text{ N/cm}^2$ (0.5 micron Hg).

A highly underexpanded plume, with an environmental chamber back pressure of $0.6 \times 10^{-5} \text{ N/cm}^2$ (0.5 micron Hg), results in an effective pressure-altitude simulation during testing at 95 km (310,000 ft).

2.2 TEST TECHNIQUE

Figure 2 is a schematic of a typical hot-flow model and the associated wave process. The charge tubes (hydrogen as the fuel and oxygen as the oxidizer) are prepared at the rated pressure required for the particular test. A

mylar diaphragm restrains the flow of the H₂ and O₂ from the mixing volume of the test model (in this case either the scaled equivalent engine or the scaled orbiter engines). A multiblade cutter ruptures the charge tube diaphragm. Although this is a multilayer, single diaphragm, each charge tube is ruptured simultaneously. The oxidizer/fuel flows into the mixing area of the system. At the same instant, an expansion wave and a shock wave are initiated at the line of the diaphragm rupture. As the process continues, the pressure rises continuously in the mixing area and combustion chamber. At a predesigned pressure level, a mylar diaphragm in the combustion chamber region at the nozzle entrance is ruptured by an overstress on the diaphragm. This second diaphragm ensures that a sharp line exists between the initial flow and choked conditions in the stagnation region of the nozzle. The initial shock proceeds down the nozzle and into the dump (environmental chamber) tank. The initial expansion wave moves simultaneously through the charge tubes in an upstream direction.

The rarefaction waves in the charge tubes proceed at different speeds, since the speed of sound in the hydrogen tube is approximately four times that in the oxygen tube. This fact is accounted for by making the hydrogen charge tube approximately four times the length of the oxygen charge tube.

As the initial shock passes a given point in the flow field (e.g., the exit plane of the nozzle), the useful run time for the test begins. The expansion waves are reflected from the closed end of the charge tubes and move downstream. The passage of the reflected waves past the initiation point (nozzle exit plane) is considered the end of the useful run time. The total process, from diaphragm rupture to the end of the useful run time is approximately 15 to 20 msec, and the useful run time is 6 to 10 msec.

2.3 INSTRUMENTATION

For a typical test, all information must be acquired within 10 msec. For these tests, a digital data acquisition system operating at either 40,000,

80,000 or 160,000 samples per second was used. The data acquisition system employed for the first phase has a 32-channel capacity and was operated at the 80,000 samples-per-second rate which gave a single channel speed of five test frames every two milliseconds. A 60-channel FM multiplex data acquisition system with a 40,000 samples-per-second rate was employed for the the second phase of testing.

Two types of pressure transducers were used during these tests. High-level pressures were measured with Kistler transducers, a piezoelectric instrument whose charge output is converted to a high-level voltage with a multi-range charge amplifier. Low level pressures were measured with Hidyne transducers, a double-coil, variable reluctance diaphragm instrument used when high sensitivity and fast response are required. Both transducers are calibrated by applying a known pressure and recording the output voltage of the transducer.

Two types of heat sensors were used in this experimental program, both were thin film units (Astro-Space Laboratories, Inc.). The heat sensors located in the leading edge of the vertical tail employed a contoured pyrex substrate that matched the airfoil section used for the tail. The other heat sensors, located on the booster fuselage and on the side of the tail, (at 40% chord) were flat-faced gages. Both sensors utilized a thin (1000 angstroms) strip of platinum flush mounted on a substrate of pyrex. The standard sensors have a nominal room temperature resistance of 100 ohms, a resistance-temperature relationship of approximately 0.18 ohm per degree Celsius, and a sensitivity of 0.0023 ohm per ohm per degree Celsius. The response time of these sensors is 0.1 to 5 microseconds.

The reference pressure of the environmental chamber was monitored with an Alphatron system, and the charge tube pressures were determined using a Bourdon tube system.

2.4 MODELS

The test models, described below, include the two 3% scaled orbiter

motors, the scaled 4.242% equivalent motor, impact probe and the aft third of a scaled 3% General Dynamics B-15B Booster. Only the aft portion of the booster was constructed since this is the only part which would experience plume impingement. The model was designed and built by Convair Aerospace so that the remaining fuselage sections could be added if future testing dictated that the complete configuration be used. An additional feature of the model allows a different wing to be attached by rotating the fuselage 180 deg about the model centerline to simulate a high wing configuration. The model fuselage and vertical tail were directly scaled. The wing was a flat plate of the correct planform, but which did not duplicate the airfoil section of the real wing.

The model was constructed of several aluminum sections and attached to a steel sting that matched the support system requirements of the IBFF.

2.4.1 Dual and Equivalent Nozzles

The analytical capabilities within the state of the art of gasdynamic analysis of nozzle flow and plume expansion flow fields do not include the capability of rapidly analyzing the resultant flow field produced by two or more interacting nozzle plumes. The fact that this flowfield analysis requires considerable computer time and is exceedingly cumbersome produces not only the basic question of how the plume properties can be determined, but also the effects of impingement. The plume expansion will intersect in basically the region of keenest interest, the near field region of $X/D_{exit} \leq 5$. Because of the complexity of the flow, the only parameters which can be used to duplicate the flowfield effect are the engine operating parameters, the engine mass flow (total) and the scale size. Although engine operating parameters do not simulate the full-scale vehicle from the standpoint of the "p-f" scaling law (Refs. 2 and 7), they are scaled for mass flows and combustion products. Since the combustion products are not altered by changes in scale size, this leaves the mass flows to be considered for scaling purposes along with geometric scaling.

Thus, to allow analytical assessment of plume properties based on operating conditions of the dual-engine assembly, the equivalent mass flow of the

dual-engine assembly must be the controlling parameter for scaling the "equivalent" nozzle. (See Fig. 3 for a schematic of the equivalent nozzle and Table 1 for the equivalent nozzle contours.) The geometry of the equivalent engine is the same as that used in the 3% model, with the scale factor based on identical mass flows resulting in a scale size of 4.242% for the single equivalent engine.

The equivalent nozzle was used for all baseline measurements and analytical analyses for plume predictions, as well as to assess operational characteristics of the overall system. These conditions were used to compare booster model impingement data with the dual-engine assembly in both vertical and horizontal orientations.

The true scaled nozzle and combustion chamber pressure would require, for actual viscous terms simulation, a pressure of $7 \times 10^4 \text{ N/cm}^2$ ($100,000 \text{ lb/in.}^2$), which is not feasible to consider. Therefore, a nominal combustion chamber pressure of 689 N/cm^2 (1000 lb/in.^2) was chosen for convenience. Since the full-scale vehicle requires a combustion chamber pressure of three times this value, 2100 N/cm^2 (3000 lb/in.^2), the pressure ratio across the jet at the exit plane referenced to freestream pressure (P_j/P_∞) is a factor of three too low to simulate the P_j/P_∞ at 73 km (240,000 ft) for the full-scale vehicle. In order to maintain the nominal pressure ratio, the environmental dump tank was maintained at a pressure corresponding to a slightly higher altitude. This pressure difference made the proper adjustment for simulating the pressure ratio required to allow the full plume expansion found at 73 km (240,000 ft) operating at a combustion chamber pressure of 2100 N/cm^2 (3000 lb/in.^2).

See Reference 23 for a complete description of the analytical techniques employed for this test program and an assessment of the analytical/experimental data.

The operating conditions and geometry of the dual and equivalent engine systems are shown in the table on the following page.

Parameter	Engine	
	Dual	Equivalent
P_0 , N/cm ² (lb/in. ²)	689.5 (1000)	689.5 (1000)
\dot{m} , gm/sec (lb/sec)	269.4 (0.592)	269.4 (0.592)
r^* , cm (in.)	0.3632 (0.1430)	0.5194 (0.2045)
A^* , cm ² (in. ²)	0.4144 (0.0642)	0.8475 (0.1314)
A/A^*	170	167
Scale, %	3	4.242

The two simulated orbiter motors (Fig. 4) utilized in these tests were 3% scale models designed by Lockheed-Huntsville Research & Engineering Center and fabricated in the NASA-MSFC shops. The baseline nozzle contour of Aerojet General's 400,000 lbs thrust engine (Ref. 24) was simulated as closely as possible (Table 2) without resorting to the extremes which would be required for scaling the surface roughness. The necessary degree of scaling the surface roughness of the models to that of the actual hardware is at present an unknown quantity (Ref. 2)*. The upstream portions of the motors, shown schematically in Fig. 5 were also not scaled. The mixing and combustion chambers were not simulated, nor were the injection systems for the fuel/oxidizer combination. The stagnation chamber pressures were different from both the full scale values and simulation requirements presented in Ref. 2 as necessary to account for nozzle Reynolds number, but the oxidizer-to-fuel ratio was correlated with that of full scale, using gaseous oxygen and hydrogen constituents for simulation purposes. This resulted in the proper combustion products and species breakdown.

2.4.2 Engine Hardware

The capability was designed into the nozzle hardware to accomplish:

*Assignment of a ± 0.005 -inch tolerance for machining purposes precluded the possibility of exactly matching the prototype contour and maintaining the same nozzle-throat-to-exit-area ratio between the two 3% engines and the equivalent engine.

- vertical engine orientation for low crossrange simulation;
- horizontal engine orientation for high crossrange simulation; and
- stored orbiter engine contour for an abort simulation.

The abort configuration is simply a shorter nozzle for this testing purpose having an area ratio, A/A^* , of 91:1. The technique for these tests was to have a separation line, as shown in Fig. 4, in order that the downstream end of the nozzle can be removed from the nozzle assembly.

The vertical and horizontal orientations are achieved by allowing the assembly plate on which the nozzles are mounted to be rotated 90 degrees.

The dual engine or equivalent engine configuration is installed by utilizing the appropriate port housing. See Fig. 5 for details.

2.4.3 Impact Probes

The plume flowfield impact pressures (pitot total) were measured with probes having the configurations shown in Fig. 6. The impact probe denoted as being Probe A was used for all near-field measurements. Probe B was used for intermediate measurements and all far-field measurements. Included in Fig. 7 is a schematic of the impact probe/orbiter nozzle axis system. The impact probe and mounting mechanism allowed the impact probe to be aligned with the flow along a given direction, which was predicted as being the angle realized by the streamlines at that locale. Figures 8, 9, and 10 are photographs of the impact probes and the equivalent nozzle, the two 3% horizontal arrangement and the two 3% vertical arrangement. Figures 11 through 34 are plots of the plume data.

2.4.4 Stagnation Point Heating Rate Probes

The stagnation point heat transfer rates for the exhaust plumes were measured with probes having the configuration shown schematically in Fig. 6

and pictorially in Fig. 8. The stagnation heating rate probes consisted of a 2.06 cm (0.81 in) diameter hemisphere-cylinder with a 0.318 cm (0.125 in) diameter flat-faced thin film heat transfer gauge located at the stagnation point.

2.4.5 Booster

The booster model employed for these tests, a 3% version of the General Dynamics low delta wing/vertical tail vehicle, is shown schematically in Figs. 35, 36 and 37 with photographs of the actual model and support system shown in Figs. 38, 39 and 40. The schematics shown in Figs. 35 and 36 indicate 100 instrumentation ports with 60 allocated for pressure and 40 for thin film heat transfer measurements.

2.5 MOTOR/BOOSTER RELATIVE TEST POSITIONS

The test positions for the plume impingement tests on the General Dynamics model are shown in Fig. 41. The dimensions listed in Fig. 41 are all relative to the exit plane of the nozzle assembly being used, whether it is the single or dual nozzle assembly.

Since the nozzle assembly was fixed, angle of incidence was obtained by moving the booster reference point centerline with respect to the orbiter engine exit plane centerline.

Figure 42 depicts the model geometry and engine arrangement for this test.

2.6 DATA TABULATION

Tables 3 and 4 are typical examples of the run log and reduced data output for the plume surveys and plume impingement tests. Because of the bulk

of data accumulated during these tests, the run logs are not included in this report. Table 5 is an index of the plume impact pressure surveys with the tabulated results included in Tables 6 through 82. Table 83 is an index of the plume impact heating rate surveys with the tabulated results included in Tables 84 through 112. Table 113 is an index of the booster impingement test conditions with the tabulated results included in Tables 114 through 179. A complete set of the run logs is available through NASA-MSFC release authorization.

The data as shown in Table 4, which is a direct copy of the original printout, are reduced with a computer program written by NASA-MSFC for compatibility with the IBFF data acquisition system.

2.7 DATA ACCURACY AND REPEATABILITY

In general, as is the case with any test facility when the test instrumentation is pushed well beyond the design limits, the accuracies and repeatabilities fall below a desired level, but the data must still be used since it is a state-of-the-art matter. Development work in the area of extremely low pressure measuring devices is an ongoing project to advance the capabilities of this facility. Results to date are extremely encouraging. In the ranges for which the present system was designed, the day-to-day accuracies and repeatabilities were within a level of $\pm 25\%$ of full scale. There are points which may be found to be outside this range, but the trends on any given test are well-defined values. The accuracy in absolute numbers represents a variable quantity. The higher pressure levels are the most accurate, with an absolute level of $\pm 10\%$. At the extreme farfield and radial locations tested, accuracies of $\pm 50\%$ represent the acceptable limits for pressure measurements since the transducers are being operated in an environment beyond their design capability. The heat transfer measurements are considered to have closer tolerances since, where the heating rates are predicted to be outside a given upper or lower limit (depending on several variables), no attempt was made to measure the values. The heat transfer results, then, are considered to be within $\pm 20\%$.

Data points found to be outside the trend of values, particularly on plume centerline measurements, can in all probability be attributed to impingement of mylar diaphragm particles on the heat sensors and into the pressure transducers.

2.8 ALIGNMENT ACCURACIES

Test hardware was aligned by optical and mechanical means relative to the exit plane of the nozzle being tested. The location tolerances for the impact probes and the booster model for the staging impingement tests were as follows:

Impact Probe

X = ± 0.125 cm (± 0.050 in.)
Y = ± 0.125 cm (± 0.050 in.)
Z = ± 0.125 cm (± 0.050 in.)
 ψ = $\pm 0^\circ$ 10 min

Booster Model

X = ± 0.125 cm (± 0.050 in.)
Y = ± 0.125 cm (± 0.050 in.)
Z = ± 0.125 cm (± 0.050 in.)
 α = $\pm 0^\circ$ 10 min

Section 3
EXPERIMENTAL RESULTS

The results of this experimental program were obtained in two phases. A new model support system was installed between the end of Phase I and the beginning of Phase II. Installation of the system required a thirty-day shutdown of the IBFF during which time a 60-channel data acquisition system was also installed. The divisions of each phase are listed below.

Phase I

- Test 019: Plume Surveys at X/D = 4, 12 and 15
Test 020: Model Impingement Tests

Phase II

- Test 021: Plume Surveys at X/D = 2, 4, 10 and 15
Test 022: Model Impingement Tests
Test 024: Plume Surveys at X/D = 1 and 2

All plume heating data presented in Figs. 29 through 34 has been normalized to a chamber pressure of 386.1 N/cm^2 (560 lb/in^2). The booster impingement pressure data are presented in Figs. 43 through 90 and the booster impingement heating data are presented in Figs. 91 through 118. The booster heating data were normalized to a chamber pressure of 689.5 N/cm^2 (1000 lb/in^2). The actual experimental values are listed in the applicable data sheets.

The normalizing equation in both cases was

$$\dot{q}_{\text{normalized}} P_c = \dot{q}_{\text{measured}} \sqrt{\frac{P_c^{\text{normalized}}}{P_c^{\text{measured}}}}$$

3.1 PLUME IMPACT PRESSURE SURVEYS

Analytical predictions of the properties of the plume flow field were compared and analyzed with these experimental results and published in Ref. 23.

The surveys of the plume flow field are listed in Table 5 and the results are listed in Tables 6 through 82. Plots of the plume survey data are shown in Figs. 11 through 28.

3.2 BOOSTER IMPINGEMENT DATA

Analytical predictions and analysis of the orbiter plume impingement on the booster were compared and analyzed with the experimental results and published in Ref. 23.

The test conditions and engine configurations to which the booster model was subjected are listed in Table 113, and the results are listed in Tables 114 through 179. Plots of the booster impingement data are shown in Figs. 43 through 90.

Full scale axial force, normal force and pitching moment data which were derived from Phase I of the test data are presented in Ref. 25.

3.3 DATA ANALYSIS/REDUCTION

The complete time history trace of run 63/0 reveals the typical data curves generated by plotting selected output from the digital data acquisition system (Fig. 119). The O₂ and H₂ charge tubes are charged to their pretest pressure of approximately 1300 psia and their output is nulled to zero. Because of the method used in calibration, a negatively increasing value of counts output represents a decreasing pressure from the 1300 psia starting point. In the case of Fig. 119, which is a reproduction of run 63/0, or the dual-vertical engine, the net output at the average value for what was considered

the test frames, was -930, and -953 counts for the charge tubes. With a sensitivity of 1.4245 and 1.4163 psi/count, respectively, these represent a net pressure reading of 1357 and 1317 psia.

The diaphragm rupture occurs in this case at approximately the 51st frame with almost instantaneous response by the instrumentation. Analysis of these curves generally begins with an inspection of the chamber pressure curve to see if it exhibits a rapid rise time to a steady state chamber pressure. Coupled with this observation is an inspection of the O₂ and H₂ curves to see if they indicate a characteristic drop in pressure followed by a subsequent leveling off and if the slopes of the two curves are somewhat "parallel" to each other. The assumption made during the O₂ and H₂ curve inspection is that if the two curves are relatively flat and parallel then this time frame represents one of a constant O/F ratio. Another measurement examined to determine the lower limit of test frame data is the P_{N₁} static pressure curve. Generally this curve corresponds to the chamber pressure curve with a possible difference occurring in the test frame number associated with the onset of instrumentation response.

To determine the upper limit of test frame data associated with a previously selected test frame range in the flat portion of the chamber pressure curve requires considerable experience and "feel" for the data curves obtained from the IBFF. For this reason a more general discussion of the remaining data analysis will be attempted. To determine the upper test frame limit on test data the pressure and temperature curves are examined individually to detect the occurrence of reflected shock effects on the test data. Remembering that the IBFF is a cylindrical tank 5.5m (18 ft) in diameter with a scaled rocket engine firing for approximately 30 milliseconds, the existence of shock waves reflected off the inside walls is a certainty. Depending upon the location of the instrumentation, axially and radially with respect to the centerline of the engines, it may be subject to reflected shocks. The influence, if any, on the data curves will be readily apparent and the test frame associated with this disturbance will represent the upper limit of test

data for that specific measurement. The test frames selected for examination and determination of the time-averaged value for that measurement will generally be in the first level portion, above the tare reading, of that curve. This level portion may correspond to the same test frame numbers selected for determination of the average chamber pressure but generally will be higher test frame numbers. This is possible due to the axial range of instrumentation and the corresponding response lag between a near and far field measurement. The number of test frames selected for determining the time-averaged value of the measurement depends upon the number of frames that correspond to a "level" curve and/or whether the cutoff limitation due to reflected shocks was encountered. The test frames selected as representative of the measurement for each pressure were time averaged using a data reduction program developed by NASA-MSFC and compatible with the IBFF measurements. The test frames selected for the temperature measurements were determined in a similar fashion and coupled with a computer program (Ref. 26) to determine the heating rates.

Section 4
CONCLUSIONS

The reported experimental test results represent, primarily, two major considerations or accomplishments. First, a demonstrated capability for short duration testing of space shuttle vehicles during separation in the Impulse Base Flow Facility has been shown, and secondly these results are representative of the type of complete studies needed to verify the analytical predictions of nozzle plume flow fields.

Some points to be considered in designing engine hardware and planning plume impingement tests are as follows. The smallest tolerances possible should be assigned for engine hardware to limit nozzle contour variations from prototype values. After the nozzle has been fabricated, the exact internal contours should be determined by, for example, pouring an RTV mold and determining the nozzle contours from an optical comparator. Data thus obtained can be used as input to the specific theoretical model employed to predict the resulting model nozzle flow field.

If mylar rupture diaphragms are employed for short duration testing, an effort should be made to ascertain if the flow field is relatively free of diaphragm particles. The introduction of any contaminants from rupture diaphragms composed of mylar or cellophane or from ignition sources will appreciably reduce the life span of thin film heat transfer gages and can result in erroneously high heat transfer measurements.

Centerline probe measurements of the plume flowfield(s) were occasionally susceptible to severe particle impingement, in some cases mylar particles were found lodged in the pressure transducers. In several cases the thin film contoured heat sensors suffered erosive pitting of the pyrex substrate and platinum sensing strip.

Occasionally the heat sensors in the rake surveys and the contoured heat sensors experienced a change in resistance (heating rate) greater than 1000 ohms from predictions. In these cases the predicted resistance change was generally an order of magnitude less than the sensor was capable of withstanding. When these sensors were examined, a completely eroded platinum strip and severely pitted pyrex substrate were found. Conversations with Cornell Aeronautical Laboratories, Inc., (Ref. 27) indicate that this is not an unusual occurrence and replacement of the thin film gages with calorimeter type gages eliminated their erosion problem.

During the latter portion of Phase II plume surveys, the IBFF personnel were able to ignite the propellants by an adiabatic compression process that elevated the propellant mixture to the ignition temperature without the use of an igniter. Since only pressure measurements were being monitored during this sequence it is too early to assess the effect of removing a potential contamination source, namely, the igniter.

Section 5
REFERENCES

1. Smoot, L. D., and R. C. Farmer, "Rocket Plume Technology," preprint 134, presented at the Symposium on Rocket Exhaust Plume Phenomena, Second Joint AIChE-11QPR Meeting, Tampa, Fla., May 1968.
2. Fan, Chien, and W. H. Sims, "Experimental Simulation of Hot Gas Jets Expanding into a Low Density Quiescent Atmosphere," LMSC-HREC D148774, Lockheed Missiles & Space Company, Huntsville, Ala., March 1969.
3. Whitehurst, Charles A., and Jeffrye Mourer, "Jet-Shock Interactions," J. Astronaut. Sci., Vol. V, No 11, March-April 1968, pp. 71-79.
4. D'Attorre, L., G. Nowak, and H. U. Thommen, "Inviscid Analysis of the Plume Created by Multiple Rocket Engines," Rep. rt GD/C-DBE-66-014, General Dynamics/Convair Div., San Diego, Calif., May 1966.
5. Goethert, B. H., "Base Flow Characteristics of Missiles with Clustered Rocket Exhausts," Aerospace Engr., March 1966.
6. Penny, M. M., "Definition of a Plume Flow Field with an External Shock Wave for a Scaled J-2 Engine Operating at High Altitude Conditions," LMSC-HREC D14896C, Lockheed Missiles & Space Company, Huntsville, Ala., July 1971.
7. Stephens, John F., "Scaling Parameters for the Simulation of Highly Expanded Rocket Exhaust Plumes and the Resultant Impingement Forces on an Immersed Body," LMSC-HREC D162424, Lockheed Missiles & Space Company, Huntsville, Ala., July 1970.
8. Pindzola, M., "Boundary Simulation Parameters for Underexpanded Jets in a Quiescent Atmosphere," AEDC-TR-65-6, Arnold Engineering Development Center, Tullahoma, Tenn., January 1965.
9. Herron, R. D., "Investigation of Jet Boundary Simulation Parameters for Underexpanded Jets in a Quiescent Atmosphere," AEDC-TR-68-108, Arnold Engineering Development Center, Tullahoma, Tenn., September 1968.
10. Ratliff, A., et al., "Analysis of Heating Rates and Forces on Bodies Subject to Rocket Exhaust Plume Impingements," LMSC-HREC A791230, Lockheed Missiles & Space Company, Huntsville, Ala., March 1968.

11. Bird, K. D., C. L. Matthis, and J. W. Reece, "The Application of Short-Duration Techniques to the Experimental Study of Base Heating; Part I, High-Altitude Testing Technique and Experimental Results for a 1-Engine Rocket Configuration," CAL Report No. HM-1510-Y-1 (I), Cornell Aeronautical Laboratory, Inc., Buffalo, N. Y., April 1962.
12. Sims, W. H., M. M. Penny and C. J. Wojciechowski, "Experimental and Analytical Results of a Scaled J-2 Plume Impingement Program in the NASA-MSFC Impulse Base Flow Facility," to be published.
13. Wojciechowski, Carl J., Morris M. Penny and Robert J. Prozan, "Space Shuttle Vehicle Rocket Plume Impingement Study for Separation Analysis," LMSC-HREC D162657, Lockheed Missiles & Space Company, Huntsville, Ala., November 1970.
14. Benefield, John W., "Plume Impingement and Jet Wake Effects on Space Shuttle," LMSC-HREC D162585, Lockheed Missiles & Space Company, Huntsville, Ala., September 1970.
15. Penny, M. M., et al., "Space Shuttle Vehicle Rocket Plume Impingement Study for Separation Analysis," LMSC-HREC D162852, Lockheed Missiles & Space Company, Huntsville, Ala., January 1971.
16. Prozan, R. J., "Development of a Method of Characteristics Solution for Supersonic Flow of an Ideal Frozen or Equilibrium Reacting Gas Mixture," LMSC-HREC D162220-III, Lockheed Missile & Space Company, Huntsville, Ala., May 1970.
17. Zeleznik, J. J., and S. Gordon, "A General IBM 704 or 7094 Computer Program for Computation of Chemical Equilibrium Compositions, Rocket Performance and Chapman-Jouguet Detonations," NASA TN D-1454, October 1962.
18. Golden, J. O., and L. W. Spradley, "Description of a Digital Computer Code for Rocket Nozzle Sudden Freezing Analysis," LMSC-HREC A784526, Lockheed Missiles & Space Company, Huntsville, Ala., 1967.
19. Fay, J. A., and F. R. Riddell, "Theory of Stagnation Point Heat Transfer in Dissociated Air," J. Aeron. Sci., Vol. 25, No. 2, February 1958.
20. Rader, R. J., "Theoretical and Experimental Stagnation Heating Rate Comparisons for the R-1E, R-4D, J-2, Sonic Orifice, and Space Shuttle Orbiter Engine Exhaust Plumes Considering Equilibrium, Frozen and Finite Rate Chemistry," LMSC-HREC D225260, Lockheed Missiles & Space Company, Huntsville, Ala., August 1971.
21. Gwin, Hal S., "Impluse Base Flow Facility Technical Handbook," TMX-53716, NASA-Marshall Space Flight Center, Huntsville, Ala., March 1968.

22. Wise, C., J. Porter and D. Mantle, "Standard Operating Procedure for the Impulse Base Flow Facility." M-794-639, Northrop Corporation, Huntsville, Ala., April 1970.
23. Penny, M. M., and C. J. Wojciechowski, "Analysis of the Results of a Space Shuttle Parallel Staging Flume Impingement Investigation," LMSC-HREC D225939, Lockheed Missiles & Space Company, Huntsville, Ala., August 1972.
24. "Preliminary Requirements Review Documentation for Space Shuttle Main Engine Definition Study - Volume 2 - Analyses and Studies," Aerojet Liquid Rocket Company, Report No. 26188-PRR, Sacramento, Calif., September 1970.
25. Turner, R. L., Jr., "Experimental Determination of the Space Shuttle Orbiter Plume Imposed Forces and Heating on the B-15B Booster During Separation," General Dynamics Convair Aerospace Division, FZA 76-003, Convair Aerospace Division, Fort Worth, Texas, December 1971.
26. Rader, R. J., "A Numerical Technique to Calculate Heating Rates Utilizing Thin-Film Heat Transfer Gages," LMSC HREC D225024, Lockheed Missiles & Space Company, Huntsville, Ala., April 1971.
27. Telephone Conversations between R. W. McCanna (Lockheed-Huntsville), and K. Hendershot, Cornell Aeronautical Laboratory, Inc., 13 January 1972.

LMSC-HREC D225839

Appendix A
TABLES

LIST OF TABLES

Table		Page
1	Equivalent Orbiter Nozzle Contour (4.242% Scale)	A-1
2	Orbiter Baseline Nozzle Contour (3% Scale)	A-2
3	Typical Run Log - IBFF Calibration Data	A-3
4	Typical Program Output Listing	A-4
5	Plume Impact Pressure Surveys	A-5
IBFF 3% GENERAL DYNAMICS BOOSTER/SEPARATION IMPINGEMENT TEST (PLUME DEFINITION)		
6	X/D = 1.0 Equivalent Engine, Run 64/2	A-9
7	X/D = 1.0 Equivalent Engine, Run 65/0	A-10
8	X/D = 1.0 Equivalent Engine, Run 66/0	A-11
9	X/D = 1.0 Equivalent Engine, Run 67/0	A-12
10	X/D = 1.0 Dual Vertical Configuration, Run 72/2	A-13
11	X/D = 1.0 Dual Vertical Configuration, Run 73/3	A-14
12	X/D = 1.0 Dual Vertical Configuration, Run 74/0	A-15
13	X/D = 1.0 Dual Vertical Configuration, Run 75/0	A-16
14	X/D = 1.0 Dual Horizontal Configuration, Run 68/1	A-17
15	X/D = 1.0 Dual Horizontal Configuration, Run 69/0	A-18
16	X/D = 1.0 Dual Horizontal Configuration, Run 71/0	A-19
17	X/D = 1.0 Dual Horizontal Configuration, Run 70/0	A-20
18	X/D = 2.0 Equivalent Engine, Run 1/0	A-21
19	X/D = 2.0 Equivalent Engine, Run 2/0	A-22
20	X/D = 2.0 Equivalent Engine, Run 3/0	A-23
21	X/D = 2.0 Equivalent Engine, Run 3/1	A-24
22	X/D = 2.0 Equivalent Engine, Run 76/0	A-25
23	X/D = 2.0 Equivalent Engine, Run 77/0	A-26
24	X/D = 2.0 Dual Vertical Configuration, Run 34/0	A-27
25	X/D = 2.0 Dual Vertical Configuration, Run 35/1	A-28
26	X/D = 2.0 Dual Vertical Configuration, Run 36/0	A-29
27	X/D = 2.0 Dual Vertical Configuration, Run 78/0	A-30

LIST OF TABLES (Continued)

Table		Page
28	X/D = 2.0 Dual Vertical Configuration, Run 79/0	A-31
29	X/D = 2.0 Dual Horizontal Configuration, Run 37/0	A-32
30	X/D = 2.0 Dual Horizontal Configuration, Run 38/0	A-33
31	X/D = 2.0 Dual Horizontal Configuration, Run 39/1	A-34
32	X/D = 2.0 Dual Horizontal Configuration, Run 80/1	A-35
33	X/D = 2.0 Dual Horizontal Configuration, Run 81/0	A-36
34	X/D = 4.0 Equivalent Engine, Run 4/0	A-37
35	X/D = 4.0 Equivalent Engine, Run 5/0	A-38
36	X/D = 4.0 Equivalent Engine, Run 6/0	A-39
37	X/D = 4.0 Equivalent Engine, Run 47/1	A-40
38	X/D = 4.0 Equivalent Engine, Run 6/1	A-41
39	X/D = 4.0 Dual Vertical Configuration, Run 5/0	A-42
40	X/D = 4.0 Dual Vertical Configuration, Run 31/0	A-43
41	X/D = 4.0 Dual Vertical Configuration, Run 32/0	A-44
42	X/D = 4.0 Dual Vertical Configuration, Run 33/0	A-45
43	X/D = 4.0 Dual Vertical Configuration, Run 49/0	A-46
44	X/D = 4.0 Dual Horizontal Configuration, Run 48/0	A-47
45	X/D = 4.0 Dual Horizontal Configuration, Run 40/0	A-48
46	X/D = 4.0 Dual Horizontal Configuration, Run 41/0	A-49
47	X/D = 4.0 Dual Horizontal Configuration, Run 42/0	A-50
48	X/D = 4.0 Dual Horizontal Configuration, Run 4/0	A-51
49	X/D = 10.0 Equivalent Engine, Run 7/0	A-52
50	X/D = 10.0 Equivalent Engine, Run 8/0	A-53
51	X/D = 10.0 Equivalent Engine, Run 9/1	A-54
52	X/D = 10.0 Equivalent Engine, Run 10/0	A-55
53	X/D = 10.0 Dual Vertical Configuration, Run 27/0	A-56
54	X/D = 10.0 Dual Vertical Configuration, Run 28/0	A-57
55	X/D = 10.0 Dual Vertical Configuration, Run 29/0	A-58
56	X/D = 10.0 Dual Vertical Configuration, Run 30/0	A-59
57	X/D = 10.0 Dual Horizontal Configuration, Run 43/0	A-60
58	X/D = 10.0 Dual Horizontal Configuration, Run 44/0	A-61
59	X/D = 10.0 Dual Horizontal Configuration, Run 45/	A-62
60	X/D = 10.0 Dual Horizontal Configuration, Run 46/0	A-63

LIST OF TABLES (Continued)

Table		Page
61	X/D = 12.0 Equivalent Engine, Run 58/0	A-64
62	X/D = 12.0 Dual Vertical Configuration, Run 62/0	A-65
63	X/D = 12.0 Dual Vertical Configuration, Run 63/0	A-66
64	X/D = 12.0 Dual Horizontal Configuration, Run 60/0	A-67
65	X/D = 15.0 Equivalent Engine, Run 1/5	A-68
66	X/D = 15.0 Equivalent Engine, Run 1/6	A-69
67	X/D = 15.0 Equivalent Engine, Run 50/0	A-70
68	X/D = 15.0 Equivalent Engine, Run 15/0	A-71
69	X/D = 15.0 Equivalent Engine, Run 16/0	A-72
70	X/D = 15.0 Equivalent Engine, Run 17/0	A-73
71	X/D = 15.0 Equivalent Engine, Run 18/0	A-74
72	X/D = 15.0 Dual Vertical Configuration, Run 2/0	A-75
73	X/D = 15.0 Dual Vertical Configuration, Run 56/0	A-76
74	X/D = 15.0 Dual Vertical Configuration, Run 57/0	A-77
75	X/D = 15.0 Dual Horizontal Configuration, Run 51/0	A-78
76	X/D = 15.0 Dual Horizontal Configuration, Run 52/0	A-79
77	X/D = 15.0 Dual Horizontal Configuration, Run 53/0	A-80
78	X/D = 15.0 Dual Horizontal Configuration, Run 54/0	A-81
79	X/D = 15.0 Dual Horizontal Configuration, Run 51/0	A-82
80	X/D = 15.0 Dual Horizontal Configuration, Run 3/1	A-83
81	X/D = 15.0 Dual Horizontal Configuration, Run 54/0	A-84
82	X/D = 15.0 Dual Horizontal Configuration, Run 55/0	A-85
83	Plume Impact Heating Rate Surveys	A-86

IBFF 3% GENERAL DYNAMICS BOOSTER/SEPARATION
IMPINGEMENT TEST (PLUME DEFINITION)

84	X/D = 4.0 Equivalent Engine, Run 6/0	A-88
85	X/D = 4.0 Dual Vertical Configuration, Run 5/0	A-89
86	X/D = 4.0 Dual Horizontal Configuration, Run 4/0	A-90
87	X/D = 10.0 Equivalent Engine, Run 11/0	A-91
88	X/D = 10.0 Equivalent Engine, Run 11/1	A-92
89	X/D = 10.0 Equivalent Engine, Run 12/0	A-93

LIST OF TABLES (Continued)

Table		Page
90	X/D = 10.0 Equivalent Engine, Run 13/0	A-94
91	X/D = 10.0 Dual Vertical Configuration, Run 25/0	A-95
92	X/D = 10.0 Dual Vertical Configuration, Run 26/0	A-96
93	X/D = 10.0 Dual Horizontal Configuration, Run 47/0	A-97
94	X/D = 10.0 Dual Horizontal Configuration, Run 48/0	A-98
95	X/D = 12.0 Equivalent Engine, Run 58/0	A-99
96	X/D = 12.0 Dual Horizontal Configuration, Run 60/0	A-100
97	X/D = 15.0 Equivalent Engine, Run 1/5	A-101
98	X/D = 15.0 Equivalent Engine, Run 1/6	A-102
99	X/D = 15.0 Equivalent Engine, Run 15/0	A-103
100	X/D = 15.0 Equivalent Engine, Run 52/0	A-104
101	X/D = 15.0 Equivalent Engine, Run 53/0	A-105
102	X/D = 15.0 Equivalent Engine, Run 14/0	A-106
103	X/D = 15.0 Dual Vertical Configuration, Run 2/0	A-107
104	X/D = 15.0 Dual Vertical Configuration, Run 23/0	A-108
105	X/D = 15.0 Dual Vertical Configuration, Run 24/0	A-109
106	X/D = 15.0 Dual Vertical Configuration, Run 25/0	A-110
107	X/D = 15.0 Dual Vertical Configuration, Run 26/0	A-111
108	X/D = 15.0 Dual Horizontal Configuration, Run 3/1	A-112
109	X/D = 15.0 Dual Horizontal Configuration, Run 49/0	A-113
110	X/D = 15.0 Dual Horizontal Configuration, Run 50/0	A-114
111	X/D = 15.0 Dual Horizontal Configuration, Run 54/0	A-115
112	X/D = 15.0 Dual Horizontal Configuration, Run 55/0	A-116
113	Booster Impingement Test Conditions	A-117

TEST POSITION 2

114	Equivalent Engine, Run 10/0	A-120
115	Equivalent Engine, Run 11/0	A-121
116	Equivalent Engine, Run 13/0	A-122
117	Equivalent Engine, Run 59/0	A-123
118	Equivalent Engine, Run 60/0	A-125
119	Dual Horizontal Configuration, Run 14/1	A-127

LIST OF TABLES (Continued)

Table		Page
120	Dual Horizontal Configuration, Run 15/0	A-129
121	Dual Horizontal Configuration, Run 17/1	A-129
<u>TEST POSITION 4</u>		
122	Equivalent Engine, Run 45/0	A-130
<u>TEST POSITION 5</u>		
123	Equivalent Engine, Run 40/0	A-131
124	Equivalent Engine, Run 41/0	A-132
125	Equivalent Engine, Run 42/0	A-133
126	Equivalent Engine, Run 87/0	A-134
127	Equivalent Engine, Run 88/0	A-136
128	Dual Horizontal Configuration, Run 18/1	A-138
129	Dual Horizontal Configuration, Run 19/0	A-139
130	Dual Horizontal Configuration, Run 20/0	A-140
<u>TEST POSITION 8</u>		
131	Dual Horizontal Configuration, Run 31/1	A-141
132	Dual Horizontal Configuration, Run 32/0	A-142
133	Dual Horizontal Configuration, Run 33/0	A-143
<u>TEST POSITION 11</u>		
134	Dual Horizontal Configuration, Run 29/0	A-144
135	Dual Horizontal Configuration, Run 30/0	A-145
<u>TEST POSITION 14</u>		
136	Equivalent Engine, Run 43/1	A-146
137	Equivalent Engine, Run 44/1	A-147
138	Dual Horizontal Configuration, Run 21/1	A-148
139	Dual Horizontal Configuration, Run 22/0	A-149
<u>TEST POSITION 15</u>		
140	Equivalent Engine, Run 27/0	A-150
141	Equivalent Engine, Run 27/1	A-151

LIST OF TABLES (Continued)

Table		Page
142	Equivalent Engine, Run 28/0	A-152
143	Equivalent Engine, Run 28/1	A-153
144	Equivalent Engine, Run 96/0	A-154
145	Equivalent Engine, Run 96/1	A-156
146	Equivalent Engine, Run 55/1	A-158
147	Equivalent Engine, Run 56/1	A-159
148	Dual Horizontal Configuration, Run 80/1	A-160
149	Dual Horizontal Configuration, Run 81/1	A-161
150	Dual Horizontal Configuration, Run 25/0	A-162
151	Dual Horizontal Configuration, Run 26/0	A-163
<u>TEST POSITION 17</u>		
152	Equivalent Engine Configuration, Run 79/0	A-164
153	Equivalent Engine Configuration, Run 79/1	A-165
154	Dual Horizontal Configuration, Run 23/1	A-166
155	Dual Horizontal Configuration, Run 24/0	A-167
156	Dual Horizontal Configuration, Run 78/0	A-168
157	Dual Horizontal Configuration, Run 78/1	A-169
158	Dual Vertical Configuration, Run 63/0	A-170
159	Dual Vertical Configuration, Run 64/0	A-171
<u>TEST POSITION 29</u>		
160	Equivalent Engine, Run 95/0	A-172
161	Equivalent Engine, Run 95/1	A-173
162	Dual Horizontal Configuration, Run 34/0	A-174
163	Dual Horizontal Configuration, Run 35/1	A-175
164	Dual Horizontal Configuration, Run 94/0	A-176
165	Dual Horizontal Configuration, Run 94/1	A-177
166	Dual Vertical Configuration, Run 93/0	A-178
167	Dual Vertical Configuration, Run 93/1	A-179

LIST OF TABLES (Concluded)

Table		Page
<u>TEST POSITION 30</u>		
168	Equivalent Engine Configuration, Run 84/0	A-180
169	Equivalent Engine Configuration, Run 84/1	A-181
170	Equivalent Engine Configuration, Run 37/0	A-182
171	Dual Horizontal Configuration, Run 36/0	A-183
172	Dual Horizontal Configuration, Run 97/0	A-184
173	Dual Horizontal Configuration, Run 97/1	A-185
174	Dual Vertical Configuration, Run 83/0	A-186
175	Dual Vertical Configuration, Run 83/1	A-187
<u>TEST POSITION 31</u>		
176	Equivalent Engine, Run 39/0	A-188
177	Equivalent Engine, Run 86/0	A-189
178	Equivalent Engine, Run 85/1	A-190
179	Dual Horizontal Configuration, Run 38/0	A-191

Table I
EQUIVALENT ORBITER NOZZLE CONTOUR (4.242% Scale)*

X (cm)	R (cm)
0.0	0.5194
0.2108	0.5867
0.5283	0.7684
0.7391	0.8941
0.7391	0.9195
0.8458	0.9804
1.1633	1.1811
1.4808	1.3805
1.7983	1.5799
2.1158	1.7780
2.4333	1.9583
2.7508	2.1323

X (cm)	R (cm)
3.0683	2.3063
3.3858	2.4727
3.7033	2.6226
4.3383	2.9032
4.9733	3.1585
5.6083	3.4036
6.2433	3.6297
6.8783	3.8430
7.5133	4.0450
8.1483	4.2355
8.7833	4.4158
9.4183	4.5834

X (cm)	R (cm)
10.6883	4.8959
11.9583	5.1829
13.2283	5.4356
14.4983	5.6668
15.7684	5.8839
17.0384	6.0820
18.3084	6.2522

* NOTE: These contour dimensions were obtained from an RTV mold of the actual nozzle.

Table 2
ORBITER BASELINE NOZZLE CONTOUR (3% SCALE)*

X (cm)	R (cm)	X (cm)	R (cm)
0.0	0.3632	2.6162	1.8326
0.0762	0.3670	2.9337	1.9710
0.1829	0.4026	3.5687	2.2289
0.3937	0.5347	4.2000	2.4727
0.6858	0.7366	4.8387	2.6924
0.7112	0.7506	5.4737	2.8943
1.0287	0.9627	6.1087	3.0747
1.3462	1.1582	6.7437	3.2436
1.6637	1.3462	7.3787	3.4061
1.9812	1.5265	8.0137	3.5560
2.2987	1.6878	8.6487	3.6906
		9.2837	3.8138
		9.9187	3.9319
		10.5537	4.0437
		11.1887	4.1491
		11.8237	4.2494
		12.4587	4.3498
		13.0937	4.4501
		13.7287	4.5491
		14.3637	4.6419
		14.9987	4.6990
		15.6337	4.7371

* NOTE: These contour dimensions were obtained from an RTV mold of the actual nozzle.

Table 3
TYPICAL RUN LOG - IBFF CALIBRATION DATA

Channel Number	Transducer Location	Zero (counts)	Input Pressure (psia)	Full-Scale Output (counts)
1	-	-	-	-
2	O ₂	4	850	- 721
3	P _C	- 6	450	738
4	H ₂	4	850	- 715
5	O _T	- 8	105	- 745
6	H _T	- 4	105	- 749
7	P _{N₁}	- 2	4	711
8	P ₁	10	0.5	714
9	P ₂	- 1	0.5	706
10	P ₃	- 6	0.5	687
11	P ₄	4	0.5	716
12	P ₅	0	0.5	696
13	P ₆	- 1	0.5	709
14	P ₇	14	0.5	720
15	P ₈	12	0.5	722
16	-	-	-	-
17	-	-	-	-
18	P ₉	- 13	0.2	692
19	P ₁₀	3	0.2	696
20	P ₁₁	- 3	0.2	695
21	P ₁₂	7	0.2	710
22	P ₁₃	- 10	0.2	680
23	P ₁₄	- 4	0.2	689
24	P ₁₅	- 2	0.2	664
25	-	-	-	-
26	P ₁₆	125	0.2	-
27	P ₁₇	0	0.2	699
28	Q ₁	-	-	-
29	-	-	-	-
30	Q ₂	-	-	-
31	Q ₃	-	-	-
32	-	-	-	-

Table 4
TYPICAL PROGRAM OUTPUT LISTING

TEST	RUN	REURN	RATE	SUGG SAMPLES PER SECOND	ENGINEERING UNITS, TAPE REMOVED				STD. DEV.	RATIO
					CHANNEL	AVERAGE	MAXIMUM	MINIMUM		
1	-1.	-1.	-1.	-1.	1.	0.0313	0.0000	0.0600	0.0000	0.0000000
	-679.	-566.	-692.	5.	497.	427	512.	7784	482.	2526
3	-829.	-924.	-615.	1.	-1.	-1.	496.	1663	493.	1017
4	-680.	-673.	-703.	6.	-479.	7137	497.	3579	461.	8397
5	-728.	-722.	-732.	3.	-1177.	2011	1196.	6422	9.	6429
6	-75.	-373.	-380.	2.	1246.	6121	1247.	0397	0.	4128433
7	514.	562.	528.	11.	2.	9455	3.	0459	0.	3055
8	96.	986.	11.	297.	-66.	0.1154	0.7465	0.6548	0.	057365
9	880.	919.	625.	26.	-78.	0.6771	0.7047	0.6404	0.	01826
10	669.	696.	334.	16.	-66.	0.5301	0.5503	0.5059	0.	0167
11	561.	578.	542.	10.	-37.	0.4200	0.4316	0.4064	0.	0116
12	272.	279.	264.	4.	-30.	0.2169	0.2216	0.2108	0.	0064372
13	347.	397.	374.	6.	-49.	0.3067	0.3137	0.2975	0.	0043
14	350.	367.	313.	9.	-56.	0.2674	0.2996	0.2757	0.	005743
15	63.	69.	59.	3.	-91.	0.0193	0.0154	0.0124	0.	00021
16	2.	2.	2.	000.	2.	0.0000	0.0000	0.0000	0.	0060000
17	3.	3.	3.	000.	3.	0.0000	0.0000	0.0000	0.	0000000
18	567.	562.	553.	9.	-122.	0.1958	0.2000	0.1918	0.	0003946
19	559.	568.	542.	6.	-46.	0.1750	0.1776	0.1715	0.	0003527
20	530.	542.	517.	7.	-28.	0.1436	0.1470	0.1376	0.	0102494
21	416.	424.	406.	5.	-35.	0.1261	0.1302	0.1251	0.	0002541
22	232.	246.	226.	9.	-218.	0.1303	0.1345	0.1270	0.	0025
23	293.	302.	295.	4.	-61.	0.1081	0.1116	0.1060	0.	0013
24	640.	661.	610.	14.	-39.	0.1804	0.1867	0.1714	0.	0041
25	14.	19.	16.	3.	-14.	0.0000	0.0000	0.0000	0.	0000000
26	127.	230.	122.	3.	-25.	0.0000	0.0000	0.0000	0.	0066666
27	121.	190.	186.	3.	-74.	0.0758	0.0777	0.0743	0.	001527
28	177.	200.	152.	15.	-4.	0.0000	0.0000	0.0000	0.	0000000
29	-262.	-762.	-767.	100.	-23.	0.0000	0.0000	0.0000	0.	0000000
30	44.	72.	39.	16.	-39.	0.0000	0.0000	0.0000	0.	0000000
31	46.	52.	36.	2.	-2.	0.0000	0.0000	0.0000	0.	0000000
32	27.	28.	27.	0.	-27.	0.0000	0.0000	0.0000	0.	0000000

A-4

Table 5
PLUME IMPACT PRESSURE SURVEYS

Table No.	X/D	Engine Config.	Run No.	Symbol	P _c (psia)	P _∞ (μHg)
6	1.0	1	64/2	□	577.9	4.0
7	1.0	1	65/0	□	695.8	5.0
8	1.0	1	66/0	□	630.5	5.0
9	1.0	1	67/0	□	662.7	2.6
10	1.0	2V	72/2	◇	620.2	4.0
11	1.0	2V	73/3	◇	658.2	4.8
12	1.0	2V	74/0	◇	606.5	4.4
13	1.0	2V	75/0	◇	658.1	2.8
14	1.0	2H	68/1	○	624.0	3.0
15	1.0	2H	69/0	○	627.6	5.0
16	1.0	2H	71/0	○	623.1	4.0
17	1.0	2H	70/	○	612.8	4.0
18	2.0	1	1/0	□	835.4	5.0
19	2.0	1	2/0	□	549.5	4.0
20	2.0	1	3/0	□	667.6	5.7
21	2.0	1	3/1	□	543.4	5.2
22	2.0	1	76/0	■	671.3	4.0
23	2.0	1	77/0	■	636.0	5.0
24	2.0	2V	34/0	◇	528.9	5.3
25	2.0	2V	35/1	◇	569.2	5.5
26	2.0	2V	36/0	◇	618.9	5.0
27	2.0	2V	78/0	◆	634.8	3.6
28	2.0	2V	79/0	◆	590.9	4.0
29	2.0	2H	37/0	○	614.9	5.0

Table 5 (Continued)
PLUME IMPACT PRESSURE SURVEYS

Table No.	X/D	Engine Config.	Run No.	Symbol	P _c (psia)	P _∞ (μHg)
30	2.0	2H	38/0	○	605.2	5.5
31	2.0	2H	39/1	○	634.2	5.5
32	2.0	2H	80/1	●	839.8	2.2
33	2.0	2H	81/0	●	601.7	5.0
34	4.0	1	4/0	□	704.7	3.0
35	4.0	1	5/0	□	541.6	4.0
36	4.0	1	6/0	□	592.7	2.5
37	4.0	1	6/0*	■	504.0	3.0
38	4.0	1	47/1*	□	530.3	1.0
39	4.0	2V	5/0*	◆	557.8	5.0
40	4.0	2V	31/0*	◇	637.9	5.2
41	4.0	2V	32/0*	◆	579.1	5.5
42	4.0	2V	33/0*	◇	5	3.0
43	4.0	2V	49/0*	◆	639.1	1.0
44	4.0	2H	48/0*	●	655.3	1.0
45	4.0	2H	40/0*	○	662.7	5.5
46	4.0	2H	41/0*	○	560.9	6.0
47	4.0	2H	42/0*	○	590.5	5.5
48	4.0	2H	4/0*	●	596.1	3.0
49	10.0	1	7/0	□	595.3	3.0
50	10.0	1	8/0	□	596.8	3.0
51	10.0	1	9/1	□	536.7	3.0
52	10.0	1	10/0	□	598.6	3.0

*Phase I

Table 5 (Continued)
PLUME IMPACT PRESSURE SURVEYS

Table No.	X/D	Engine Config.	Run No.	Symbol	P _c (psia)	E _∞ (μHg)
53	10.0	2V	27/0	◆	708.5	1.0
54	10.0	2V	28/0	◇	682.9	5.0
55	10.0	2V	29/0	◆	731.7	2.0
56	10.0	2V	30/0	◇	669.6	3.0
57	10.0	2H	43/0	○	618.7	5.0
58	10.0	2H	44/0	●	675.4	3.2
59	10.0	2H	45/0	●	626.7	5.5
60	10.0	2H	46/0	●	682.1	5.0
61	12.0	1	58/0*	□	577.2	2.0
62	12.0	2V	62/0*	◆	656.5	7.0
63	12.0	2V	63/0*	◇	658.4	4.5
64	12.0	2H	60/0	○	620.6	2.0
65	15.0	1	1/5*	□	608.5	6.5
66	15.0	1	1/6*	■	542.0	6.0
67	15.0	1	60/0	■	527.3	1.0
68	15.0	1	15/0	□	607.6	5.0
69	15.0	1	16/0	□	604.3	3.0
70	15.0	1	17/0	□	604.1	10.0
71	15.0	1	18/0	■	638.0	3.0
72	15.0	2V	2/0*	◆	534.4	5.5
73	15.0	2V	53/0*	◇	697.4	1.0
74	15.0	2V	57/0*	◆	661.3	2.0
75	15.0	2H	51/0	○	757.5	5.0

* Phase I

Table 5 (Concluded)
PLUME IMPACT PRESSURE SURVEYS

Table No.	X/D	Engine Config.	Run No.	Symbol	P _c (psia)	P _x (μ Hg)
76	15.0	2H	52/0	○	725.0	5.0
77	15.0	2H	53/0	○	725.9	2.0
78	15.0	2H	54/0	○	737.9	3.0
79	15.0	2H	51/0*	●	434.8	2.1

*Phase I

Table 6

IBPF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	ρ_0 (lb/in. ³)	ρ_0/ρ_c	q (Btu/in. ² -sec.)
X = 5.298 in.	0	0	0	0	$1,004 \times 10^{-2}$
D = 5.298 in.	2.12	.400	2	36	$6,577 \times 10^{-3}$
X/D = 1	3.15	.600	9	30	2.222×10^{-3}
O/F = 6.0:1	4.24	.800	20	54	$6,681 \times 10^{-4}$
P _{ambient} = 4.0 Microns	5.04	.950	28	0	2.832×10^{-4}
P _{combustion} = 577.9 psia	5.84	1.100	35	0	8.932×10^{-5}
Engine Type: Equivalent	6.26	1.200	36	24	$1,003 \times 10^{-4}$
	7.125	1.350	37	37	$6,185 \times 10^{-4}$

Table 7

IBPF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)		R (in.)	R/D	(deg)	0 (min.)	P'_o/P_c	q (Btu/ft ² -sec.)
Facility Parameters							
X = 5.298 in.		0	0	0	0	1.138×10^{-2}	
D = 5.298 in.		2.12	.400	2	36	1.237×10^{-3}	
X/D = 1		3.15	.600	9	30	Out	
O/F = 6.0:1		4.24	.800	20	54	5.685×10^{-4}	
P _{Ambient} = 5.0 Microns		5.04	.950	28	0	2.616×10^{-4}	
P _{combustion} = 695.3 psia		5.84	1.100	35	0	1.117×10^{-4}	
Engine Type: Equivalent		6.26	1.200	36	24	6.295×10^{-5}	
		7.125	1.350	37	37	1.126×10^{-6}	

Table 8

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)					
Facility Parameters		R (in.)	R/D	0 (deg)	0 (min.)
				P'_0/P_c	q (Btu/ $ft^2\text{-sec}$)
X = 5.298 in.		0		0	0
D = 5.298 in.		2.12	.400	2	36
X/D = 1		3.15	.600	9	30
O/F = 6.0:1		4.24	.800	20	54
P _{ambient} = 5.0 Microns		5.04	.950	28	0
P _{combustion} = 630.5 psia		5.84	1.100	35	0
Engine Type: Equivalent		6.26	1.200	36	24
		7.125	1.350	37	37

Table 9

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	0		P'_0/P_c	q (Btu/ft ² -sec)
			(deg)	(min.)		
X = 5.298 in.	0	0	0	0	1.224 x 10 ⁻²	—
D = 5.298 in.	2.12	.400	2	36	6.287 x 10 ⁻³	—
X/D = 1	3.15	.600	9	30	1.992 x 10 ⁻³	—
O/F = 6.0:1	4.24	.800	20	54	5.695 x 10 ⁻⁴	—
P _{Ambient} = 2.6 Microns	5.04	.950	28	0	2.695 x 10 ⁻⁴	—
P _{combustion} = 662.7 psia	5.84	1.100	35	0	1.168 x 10 ⁻⁴	—
Engine Type: Equivalent	6.25	1.200	36	24	3.231 x 10 ⁻⁴	—
	7.125	1.350	37	37	2.829 x 10 ⁻⁵	—

Table 10

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	0		P_o/P_c	ϵ_i (Btu/ f_1^2 -sec)
			(deg)	(min.)		
X = 5.298 in.	0		0	0	4.997×10^{-3}	
D = 5.298 in.	2.12	.400	2	36	1.074×10^{-2}	
X/D = 1	3.15	.600	9	30	6.884×10^{-3}	
O/F = 6.0:1	4.24	.800	20	54	3.361×10^{-3}	
P _{Ambient} = 4.0 Microns	5.04	.950	28	0	1.152×10^{-3}	
P _{combustion} = 620.2 psia	5.84	1.100	35	0	5.935×10^{-4}	
Engine Type: 2V-3%	6.26	1.200	36	24	3.053×10^{-4}	
	7.125	1.350	37	37	1.052×10^{-4}	

Table 11
IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	0 (deg)	0 (min.)	P _o '/P _c	q (Btu/ft ² -sec)
X = 5.298 in.	0	0	0	0	3.409 × 10 ⁻³	—
D = 5.298 in.	2.12	.400	2	36	9.888 × 10 ⁻³	—
X/D = 1.0	3.15	.600	9	30	7.129 × 10 ⁻³	—
O/F = 6.0:1	4.24	.800	20	54	3.222 × 10 ⁻³	—
P _{Ambient} = 4.8 Microns	5.04	.950	28	0	1.160 × 10 ⁻³	—
P _{combustion} = 658.2 psia	5.84	1.100	35	0	4.619 × 10 ⁻⁴	—
Engine Type: 2V-3%	6.26	1.200	36	24	6.277 × 10 ⁻⁵	—
	7.125	1.350	37	37	3.311 × 10 ⁻⁵	—

Table 12

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	0		P'_o/P_c	q (Btu/ ft^2 -sec)
			(deg)	(min.)		
X = 5.298 in.	0	0	0	0	4.422×10^{-3}	
D = 5.298 in.	2.12	.400	2	36	1.088×10^{-2}	
X/D = 1	3.15	.600	9	30	8.256×10^{-3}	
O/F = 6.0:1	4.24	.800	20	54	2.981×10^{-3}	
P ambient = 4.4 Microns	5.04	.950	28	0	1.349×10^{-3}	
P combustion = 606.5 psia	5.84	1.100	35	0	5.614×10^{-4}	
Engine Type: 2V-3%	6.26	1.200	36	24	6.633×10^{-5}	
	7.125	1.350	37	37	6.194×10^{-5}	

Table 13

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	X (in.)	R/D	Q		P'_o/P_c	q (Btu/ $ft^2 \cdot sec$)
			(deg)	(min.)		
X = 5.298 in.	0	0	0	0	3.819×10^{-3}	—
D = 5.298 in.	2.12	.400	2	36	9.176×10^{-3}	—
X/D = 1	3.15	.600	9	30	6.813×10^{-3}	—
O/F = 6.0:1	4.24	.800	20	54	3.528×10^{-3}	—
P ambient = 2.8 Microns	5.04	.950	28	0	1.206×10^{-3}	—
P combustion = 658.1 psia	5.84	1.100	35	0	4.973×10^{-4}	—
Engine Type: 2V-3%	6.26	1.200	36	24	3.146×10^{-4}	—
	7.125	1.350	37	37	9.572×10^{-5}	—

Table 14
IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R _c (in.)	R/D	θ (deg)	t _{min.}	P _o /P _c	q (Btu/ft ² -sec)
X = 5.298 in.	0	0	0	0	4.263 × 10 ⁻³	—
D = 5.298 in.	2.12	.400	2	36	1.659 × 10 ⁻³	—
X/D = 1	3.15	.600	9	30	5.079 × 10 ⁻⁴	—
O/F = 6.0:1	4.24	.800	20	54	3.049 × 10 ⁻⁴	—
P _{ambient} = 3.0 Microns	5.04	.950	28	0	1.486 × 10 ⁻⁴	—
P _{combustion} = 624.0 psia	5.84	1.100	35	0	9.390 × 10 ⁻⁵	—
Engine Type: 2H-3%	6.26	1.200	36	24	1.020 × 10 ⁻⁴	—
	7.125	1.350	37	37	3.634 × 10 ⁻⁵	—

Table 15

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ		P'_o/P_c (Btu/ft ² -sec)	q (Btu/ft ² -sec)
			(deg)	(min.)		
X = 5.298 in.	0	0	0	0	3.297 x 10 ⁻³	—
D = 5.298 in.	2.12	.400	2	36	1.703 x 10 ⁻³	—
X/D = 1	3.15	.600	9	30	5.075 x 10 ⁻⁴	—
O/F = 6.0:1	4.24	.800	20	54	3.205 x 10 ⁻⁴	—
P _{Ambient} = 5.0 Microns	5.04	.950	28	0	1.539 x 10 ⁻⁴	—
P _{combustion} = 627.6 psia	5.84	1.100	35	0	9.747 x 10 ⁻⁵	—
Engine Type: 2H-3%	6.26	1.200	36	24	9.476 x 10 ⁻⁵	—
	7.125	1.350	37	37	2.794 x 10 ⁻⁵	—

Table 16

IBFF 3% Gen: Dynamic Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	θ (min.)	P'_o/P_c	q'_i (Btu/ft ² -sec)
X = 5.298 in.	0	0	0	0	3.341×10^{-2}	—
D = 5.298 in.	2.12	.400	2	36	1.756×10^{-3}	—
X/D = 1	3.15	.600	9	30	4.842×10^{-4}	—
O/F = 6.0:1	4.24	.800	20	54	3.281×10^{-4}	—
P _{Ambient} = 4.0 Microns	5.04	.950	28	0	1.469×10^{-4}	—
P _{combustion} = 623.1 psia	5.84	1.100	35	0	1.009×10^{-4}	—
Engine Type: 2H-3%	6.26	1.200	36	24	9.831×10^{-5}	—
	7.125	1.350	37	37	3.497×10^{-5}	—

Table 17

IBFF 3% General Dynamics Booster/Separator Impingement Test (Plume Definition)					
Facility Parameters	R (in.)	R/D	0 (deg.) (min.)	P'/P_c	q (Btu/ft ² -sec)
X = 5.298 in.	0	0	0	2.635 x 10 ⁻³	
D = 5.298 in.	2.12	.400	2	1.152 x 10 ⁻³	
X/D = 1	3.15	.600	9	4.526 x 10 ⁻⁴	
O/F = 6.0:1	4.24	.800	20	2.396 x 10 ⁻⁴	
P _{ambient} = 4.0 Microns	5.04	.950	28	1.767 x 10 ⁻⁴	
P _{combustion} = 612.8 psia	5.84	1.100	35	0	1.030 x 10 ⁻⁴
Engine Type: 2H-3%	6.26	1.200	36	24	2.974 x 10 ⁻⁶
	7.125	1.350	37	37	3.792 x 10 ⁻⁵

Table 18

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	0 (deg)	0 (min.)	P_1/P_S	q_1 (Btu/ $\text{ft}^2\text{-sec}$)
X = 10.596 in.	0	0	0	0	1.004×10^{-2}	—
D = 5.298 in.	2.55	.481	5	30	2.694×10^{-3}	—
X/D = 2	3.75	.708	10	45	Out	—
O/F = 6.0:1	5.00	.944	17	12	6.977×10^{-4}	—
P _{ambient} = 5.0 Microns	6.190	1.168	23	30	3.269×10^{-4}	—
P _{combustion} = 835.4 psia	6.875	1.298	27	12	2.433×10^{-4}	—
Engine Type: Equivalent	8.063	1.522	33	48	1.139×10^{-4}	—
	9.375	1.770	37	30	6.656×10^{-5}	—

Table 19

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)					
Facility Parameters	R (in.)	R/D	θ (deg)	min.	P ₀ /P _C
	0	0	0	0	(Btu/lb·hr ²)
X = 10.596 in.	0	0	0	9.922 × 10 ⁻³	—
D = 5.298 in.	2.55	.481	5	3.016 × 10 ⁻³	—
X/D = 2	3.75	.708	10	1.382 × 10 ⁻³	—
O/F = 6.0:1	5.00	.944	17	5.664 × 10 ⁻⁴	—
P _{Ambient} = 4.0 Microns	6.190	1.168	23	3.082 × 10 ⁻⁴	—
P _{Combustion} = 549.5 psia	6.875	1.298	27	2.287 × 10 ⁻⁴	—
Engine Type: Equivalent	8.063	1.522	33	4.8 × 10 ⁻⁴	—
	9.375	1.770	37	6.312 × 10 ⁻⁵	—

Table 20

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	0 (deg)	0 (min.)	P'_0/P_c	q (Btu/ft ² sec.)
X = 10.596 in.	0		0	0	9.764×10^{-3}	—
D = 5.298 in.	2.55	.481	5	30	3.198×10^{-3}	—
X/D = 2	3.75	.708	10	45	1.484×10^{-3}	—
O/F = 6.0:1	5.00	.944	17	12	7.853×10^{-4}	—
P _{Ambient} = 5.7 Microns	6.190	1.168	23	30	3.603×10^{-4}	—
P _{Combustion} = 667.6 psia	6.875	1.298	27	12	3.055×10^{-4}	—
Engine Type: Equivalent	8.063	1.522	33	48	1.489×10^{-4}	—
	9.375	1.770	37	30	9.603×10^{-5}	—

Table 21

Facility Parameters	R (in.)	R/D	0		P'_o/P_c	q (Btu/ft ² ·sec.)
			(deg)	(min.)		
X = 10.596 in.	0		0	0	1.01×10^{-2}	
D = 5.298 in.	2.55	.481	5	3.0	3.419×10^{-3}	
X/D = 2	3.75	.708	10	45	1.366×10^{-3}	
O/F = 6.0:1	5.00	.944	17	12	6.464×10^{-4}	
P ambient = 5.2 Microns	6.190	1.168	23	30	2.984×10^{-4}	
P combustion = 543.4 psia	6.875	1.298	27	12	2.941×10^{-4}	
Engine Type: Equivalent	8.063	1.522	33	48	1.073×10^{-4}	
	9.375	1.770	37	30	7.186×10^{-5}	

Table 22

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	0		P'_o/P_c	q (Btu/ft ² -sec)
			(deg)	(min.)		
X = 10.596 in.	0	0	0	0	Out	—
D = 5.298 in.	1.25	.240	2	30	6.839×10^{-3}	—
X/D = 2	1.75	.330	3	48	5.603×10^{-3}	—
O/F = 6.0:1	2.48	.470	7	12	3.647×10^{-3}	—
P _{Ambient} = 4.0 Micron	7.50	1.420	30	0	7.506×10^{-5}	—

P_{combustion} = 671.3 psia

Engine Type: Equivalent

Table 23

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)		R/D (in.)	R/D (deg)	P'_o/l (min.)	$P'_o/l \cdot C$	q (Btu/ft ² -sec)
Facility Parameters	0 (min.)					
X = 10.596 in.	0	0	0	0	Out	
D = 5.298 in.	1.25	.240	2	3.0	8.985×10^{-3}	
X/D = 2	1.75	.330	3	4.8	6.653×10^{-3}	
O/F = 6.0:1	2.48	.470	7	12	3.808×10^{-3}	
P _{Ambient} = 5.0 Microns	7.50	1.420	30	0	7.988×10^{-5}	
P _{combustion} = 636.0 psia						
Engine Type: Equivalent						

Table 24
IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_o/P_c	q (Btu/ft ² - sec.)
X = 10.596 in.	0	0	0	0	1.052 x 10 ⁻³	—
D = 5.298 in.	2.55	.481	5	30	Out	—
X/D = 2	3.75	.708	10	45	3.234 x 10 ⁻³	—
O/F = 6.0:1	5.00	.944	17	12	1.263 x 10 ⁻³	—
P _{Ambient} = 5.3 Microns	6.190	1.168	23	30	5.966 x 10 ⁻⁴	—
P _{Combustion} = 528.9 psia	6.875	1.298	27	12	4.419 x 10 ⁻⁴	—
Engine Type: 2V - 3%	8.063	1.522	33	48	1.617 x 10 ⁻⁴	—
	9.375	1.770	37	30	6.656 x 10 ⁻⁵	—

Table 25
IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	0 (min.)	P'_o/P_c	q (Btu/ft ² -sec.)
X = 10.596 in.	0	0	0	0	3.187×10^{-3}	—
D = 5.298 in.	2.55	.481	5	30	Out	—
X/D = 2	3.75	.708	10	45	2.716×10^{-3}	—
O/F = 6.0:1	5.00	.944	17	12	1.246×10^{-3}	—
P ambient = 5.5 Micro. psia	6.190	1.168	23	30	5.554×10^{-4}	—
P combustion = 569.2 psia	6.875	1.298	27	12	4.018×10^{-4}	—
Engine Type: 2V - 3%	8.063	1.522	33	48	1.634×10^{-4}	—
	9.375	1.770	37	30	7.159×10^{-5}	—

Table 26
IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg.)	P_o/P_c	q (Btu/ft ² -sec.)
X = 10.596 in.	0	0	0	2.827 x 10 ⁻³	
D = 5.298 in.	2.55	.481	5	Out	—
X/D = 2	3.75	.708	10	4.5	3.526 x 10 ⁻³
O/F = 6.0:1	5.00	.944	17	12	1.166 x 10 ⁻³
P ambient = 5.0 Microns	6.190	1.168	23	30	6.176 x 10 ⁻⁴
P combustion = 618.9 psia	6.875	1.298	27	12	3.860 x 10 ⁻⁴
Engine Type: 2V - 3%	8.063	1.522	33	48	1.744 x 10 ⁻⁴
	9.375	1.770	37	30	7.509 x 10 ⁻⁵

Table 27

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	t (min.)	P'_o/P_c	q (Btu/ft ² -sec)
X = 10.596 in.	0	0	0	0	Out	—
D = 5.298 in.	1.25	.240	2	30	3.337×10^{-3}	—
X/D = 2	2.48	.470	7	12	6.738×10^{-3}	—
O/F = 6.0:1	7.50	1.420	30	0	Out	—
P _{ambient} = 3.6 Microns						
P _{combustion} = 634.8 psia						
Engine Type: 2V-3%						

Table 28

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)					
Facility Parameters	R (in.)	R/D	0 (deg)	0 (min.)	P'_0/P_c (Btu/ft ² -sec)
X = 10.596 in.	0	0	0	0	Out
D = 5.298 in.	1.25	.24	2	30	3.316×10^{-3}
X/D = 2	2.48	.47	7	12	4.702×10^{-3}
O/F = 6.0:1	7.50	1.42	30	0	3.256×10^{-4}
P _{Ambient} = 4.0 Microns					
P _{combustion} = 590.9 psia					
Engine Type: 2V-3%					

Table 29

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_0/P_C	q (Btu/ft ² - sec)
X = 10,596 in.	0	0	0	0	2.933 x 10 ⁻³	—
D = 5,298 in.	2.55	.481	5	30	1.677 x 10 ⁻³	—
X/D = 2	3.75	.708	10	45	6.623 x 10 ⁻⁴	—
O/F = 6.0:1	5.00	.944	17	12	2.711 x 10 ⁻⁴	—
P _{ambient} = 5.0 Microns	6.190	1.168	23	30	2.808 x 10 ⁻⁴	—
P _{combustion} = 614.9 psia	6.875	1.298	27	12	2.289 x 10 ⁻⁴	—
Engine Type: 2H - 3%	8.063	1.522	33	48	1.257 x 10 ⁻⁴	—
	9.375	1.770	37	30	7.059 x 10 ⁻⁵	—

Table 30

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg) (min.)	P'_o/P_z	q (Btu/ft ² -sec.)
X = 10.596 in.	0	0	0 0	2.957 x 10 ⁻³	—
D = 5.208 in.	2.55	.481	5 30	2.060 x 10 ⁻³	—
X/D = 2	3.75	.708	10 45	6.557 x 10 ⁻⁴	—
O/F = 6.0:1	5.00	.944	17 12	2.915 x 10 ⁻⁴	—
F _{ambient} = 5.5 Microns	6.190	1.168	23 30	2.836 x 10 ⁻⁴	—
P _{combustion} = 605.2 psia	6.875	1.298	27 12	2.183 x 10 ⁻⁴	—
Engine Type: 2H - 3%	8.063	1.522	33 48	1.181 x 10 ⁻⁴	—
	9.375	1.770	37 30	6.607 x 10 ⁻⁵	—

Table 31

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	α (deg)	P'_0/P_c	q (Btu/ft ² -sec)
X = 10.596 in.	0	0	0	3.072 x 10 ⁻³	—
D = 5.298 in.	2.55	.481	5	1.889 x 10 ⁻³	—
X/D = 2	3.75	.708	10	7.619 x 10 ⁻⁴	—
O/F = 6.0:1	5.00	.944	17	4.863 x 10 ⁻⁴	—
P _{Ambient} = 5.5 Microns	6.190	1.168	23	3.0	2.723 x 10 ⁻⁴
P _{Combustion} = 634.2 psia	6.875	1.298	27	12	2.328 x 10 ⁻⁴
Engine Type: 2H - 3%	9.375	1.770	37	30	6.054 x 10 ⁻⁵

Table 32

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R _g (in.)	R/D	θ (deg)	0	P' _g /P _c	Q _g (Btu/lb ² ·sec)
X = 10,596 in.	0	0	0	0	2.982 × 10 ⁻³	—
D = 5,298 in.	1.25	.240	2	30	2.029 × 10 ⁻³	—
X/D = 2	1.75	.330	3	48	1.813 × 10 ⁻³	—
O/F = 6.0:1	2.48	.470	7	12	1.325 × 10 ⁻³	—
P _{Ambient} = 2.2 Microns	7.50	1.420	30	0	1.836 × 10 ⁻⁴	—
P _{combustion} = 839.8 psia						
Pipe Type: 2H-3%						

Table 33

IBFF 3% General Dynamic Booster/Separation Impingement Test (Plume Definition)						q (Btu/(ft ² -sec))
Facility Parameters	R (in.)	R/D	0 (deg)	0 (min.)	P' ₀ /P _c	
X = 10.596 in.	0	0	0	0	2.463 x 10 ⁻³	
D = 5.298 in.	1.25	.240	2	30	1.439 x 10 ⁻³	
X/D = 2	1.75	.330	3	48	1.429 x 10 ⁻³	
O/F = 6.0:1	2.48	.470	7	12	1.109 x 10 ⁻³	
P _{ambient} = 5.0 Micropsi	7.50	1.420	30	0	1.726 x 10 ⁻⁴	
P _{combustion} = 601.7 psia						
Engine Type:	2H-3%					

Table 34
IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	θ (min.)	P'_0/P_c	q (Btu/ft ² -sec.)
X = 21.192 in.	0		0	0	2.168×10^{-3}	—
D = 5.298 in.	2.50	.472	8	54	2.166×10^{-3}	—
X/D = 4	5.00	.945	13	54	5.617×10^{-4}	—
O/F = 6.0:1	7.50	1.416	18	24	3.473×10^{-4}	—
P _{Ambient} = 3.0 Microns	12.38	2.340	25	0	8.566×10^{-5}	—
P _{Combustion} = 704.7 psia	17.50	3.310	38	24	7.107×10^{-6}	—
Engine Type: Equivalent	22.45	4.240	41	36	8.36×10^{-7}	—

Table 35

IBFF 3% General Dynamics Booster/Separation Impingement Test (Volume Definition)					
Facility Parameters	R (in.)	R/D	θ (deg)	0	P_o/P_c
X = 21.192 in.	0		0	0	2.118×10^{-3}
D = 5.298 in.	2.50	.472	8	54	2.132×10^{-3}
X/D = 4	5.00	.945	13	54	6.151×10^{-4}
O/F = 6.0:1	7.50	1.416	18	24	3.485×10^{-4}
P _{ambient} = 4.0 Microns	12.38	2.340	25	0	7.585×10^{-5}
P _{combustion} = 541.6 psia	17.50	3.310	38	24	7.528×10^{-6}
Engine Type: Equivalent	22.45	4.240	41	36	1.639×10^{-6}

Table 36

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R. (in.)	R/D	0 (deg)	0 (min.)	P _{0'} /P _c	q (Btu/ft ² ·sec.)
X = 21.192 in.	0		0	0	2.259 x 10 ⁻³	—
D = 5.298 in.	2.50	.472	8	54	2.349 x 10 ⁻³	—
X/D = 4	5.00	.945	13	54	4.059 x 10 ⁻⁴	—
O/F = 6.0:1	7.50	1.416	18	24	3.288 x 10 ⁻⁴	—
P _{ambient} = 2.5 Microns	12.38	2.340	25	0	7.753 x 10 ⁻⁵	—
P _{combustion} = 592.7 psia	17.50	3.310	38	24	Out	—
Engine Type:	Equivalent	22.45	4.240	41	36	1.470 x 10 ⁻⁶

Table 37^w

Facility Parameters	R (in.)	R/D	IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)		
			θ (deg)	t _{min.}	P ₀ '/P _c (Btu/ft ² -sec) q
X = 21.238 in.	0	0	0	0	1.23 x 10 ⁻³
D = 5.298 in.	2.50	.472	9	6	2.36 x 10 ⁻³
X/D = 4	5.00	.945	13	3	1.04 x 10 ⁻³
O/F = 6.0:1	7.50	1.416	18	35	2.94 x 10 ⁻⁴
P _{ambient} = 1.0 Micron	11.44	2.162	29	3	6.49 x 10 ⁻⁵
P _{combustion} = 530.3 psia	17.10	3.310	38	36	5.57 x 10 ⁻⁶
Engine Type: Equivalent	22.50	4.250	41	0	1.54 x 10 ⁻⁶

* Phase I

Table 38^{*}
IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ		P_o^1/P_c	c_1 (Btu/ $ft^2 \cdot sec$)
			(deg)	(min.)		
X = 21.238 in.	0	0	0	0	4.505×10^{-3}	—
D = 5.298 in.	1.60	.302	5	36	3.992×10^{-3}	—
X/D = 4	3.14	.593	10	50	2.225×10^{-3}	—
O/F = 6.0:1	5.328	1.006	14	55	7.905×10^{-4}	—
P _{Ambient} = 3.0 Microns	7.421	1.401	18	30	4.379×10^{-4}	—
P _{combustion} = 504.0 psia	13.645	2.576	31	0	3.625×10^{-5}	—
Engine Type: Equivalent	18.515	3.495	40	20	—	2.6

* Phase I

Table 3^a

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	0		P'_o/P_c (Btu/ft ² -sec)	c_1 (Btu/ft ² -sec)
			(deg)	(min.)		
X = 21.238 in.	0	0	0	0	3.038×10^{-3}	—
D = 5.298 in.	1.60	.302	5	36	2.904×10^{-3}	—
X/D = 4	3.14	.593	10	50	2.160×10^{-3}	—
O/F = 6.0:1	5.328	1.006	14	55	7.957×10^{-4}	—
P ambient = 5.0 Microns	7.421	1.401	18	30	4.238×10^{-4}	—
P combustion = 557.8 psia	13.645	2.576	31	0	5.205×10^{-5}	—
Engine Type: 2V - 3%	18.515	3.495	40	20	—	4.26

*Phase I

Table 40^{**}

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ		P'_o/P_c	q (Btu/in. ² -sec.)
			(deg)	(min.)		
X = 21.192 in.	0	0	0	0	2.691 x 10 ⁻³	—
D = 5.298 in.	2.50	.472	8	54	9.524 x 10 ⁻⁴	—
X/D = 4	5.00	.945	13	54	7.445 x 10 ⁻⁴	—
O/F = 6.0:1	7.50	1.416	18	24	Out	—
P _{ambient} = 5.2 Microns	12.38	2.340	25	0	1.145 x 10 ⁻⁴	—
P _{combustion} = 637.9 psia	17.50	3.310	38	24	Out	—
Engine Type: 2V-3%	22.45	4.240	41	36	1.639 x 10 ⁻⁶	—

*Phase I

Table 41 *

Facility Parameters	R (in.)	R/D	0		P'_o/P_c	q (Btu/ft ² -sec.)
			(deg.)	(min.)		
X = 21.192 in.	0	0	0	0	3.680×10^{-3}	—
D = 5.298 in.	2.50	.472	8	54	1.128×10^{-3}	—
X/D = 4	5.00	.945	13	54	6.749×10^{-4}	—
O/F = 6.0:1	7.50	1.416	18	24	Out	—
P _{ambient} = 5.5 Microns	12.38	2.340	25	0	9.774×10^{-5}	—
P _{combustion} = 678.1 psia	17.50	3.310	38	24	1.178×10^{-5}	—
Engine Type: 2V-3%	22.45	4.240	41	36	1.686×10^{-6}	—

*Phase I

Table 42 **
IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_o/P_c	q (Btu/ft ² -sec.)
X = 21.192 in.	0	0	0	0	2.565×10^{-3}	—
D = 5.298 in.	2.50	.472	8	54	1.025×10^{-3}	—
X/D = 4	5.00	.945	13	54	8.994×10^{-4}	—
O/F = 6.0:1	7.50	1.416	18	24	4.609×10^{-4}	—
P _{Ambient} = 3.0 Microns	12.38	2.340	25	0	9.566×10^{-5}	—
P _{combustion} = 804.5 psia	17.50	3.310	38	24	Out	—
Engine Type: 2V-3%	22.45	4.240	41	36	1.312×10^{-6}	—

*Phase I

Table 4.3 **

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	t (min.)	P'_0/P_c	q (Btu/ft ² -sec)
X = 21.238 in.	0	0	0	0	4.19×10^{-3}	—
D = 5.798 in.	2.5	.472	9	6	1.81×10^{-3}	—
X/D = 4	5.0	.945	13	3	2.21×10^{-3}	—
O/F = 6.0:1	7.5	1.416	18	35	4.53×10^{-5}	—
P _{Ambient} = 1.0 Micron	11.44	2.162	29	3	Out	—
P _{combustion} = 639.1 psia	17.50	3.310	38	36	Out	—
Engine Type: 2V - 3%	22.5	4.250	41	0	Out	—

* Phase I

Table 44 *

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)					
Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_o/P_c (Btu/ft ² -sec)
X = 21.238 in.	0	0	0	0	1.48×10^{-3}
D = 5.298 in.	2.50	.472	9	6	1.74×10^{-3}
X/D = 4	5.00	.945	13	3	6.02×10^{-4}
O/F = 6.0:1	7.50	1.416	18	35	2.99×10^{-5}
P _{Ambient} = 1.0 Micron	11.44	2.162	29	3	7.94×10^{-5}
P _{combustion} = 655.3 psia	17.50	3.310	38	36	7.66×10^{-6}
Engine Type: 2H - 3%	22.50	4.250	41	0	2.81×10^{-6}

* Phase I.

Table 45 *

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)		R (in.)	R/D	6 (deg)		P'_o/P_c	q (Btu/ft ² -sec.)
Facility Parameters				deg	min.		
X = 21.192 in.		0		0	0	3,103 x 10 ⁻³	—
D = 5.298 in.		2.50	.472	8	54	2,351 x 10 ⁻³	—
X/D = 4		5.00	.945	13	54	9,157 x 10 ⁻⁴	—
O/F = 6.0:1		7.50	1.416	18	24	3,603 x 10 ⁻⁴	—
P _{Ambient} = 5.5 Microns		12.38	2.340	25	0	1.075 x 10 ⁻⁴	—
P _{Combustion} = 662.7 psia		17.50	3.310	38	24	Out	—
Engine Type: 2H - 3%		22.45	4.240	41	36	Out	—

* Phase I

Table 46

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	θ (in.)	P'_0/P_c	Q (lb/sec.)
X = 21.192 in.	0	0	0	0	3.244 x 10 ⁻³	—
D = 5.298 in.	2.50	.472	8	54	2.442 x 10 ⁻³	—
X/D = 4	5.00	.945	13	54	6.417 x 10 ⁻⁴	—
O/F = 6.0:1	7.50	1.416	18	24	3.579 x 10 ⁻⁴	—
P ambient = 6.0 Microne	12.38	2.340	25	0	1.159 x 10 ⁻⁴	—
P combustion = 560.9 psia	17.50	3.310	38	24	Out	—
Engine Type: 2H-3%	22.45	4.240	41	36	Out	—

Phase I

Table 47

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg.)	(min.)	P_1/P_{∞}	$(\text{lb}/(\text{ft}^2 \cdot \text{sec}))$
X = 21.192 in.	0	0	0	0	2.760×10^{-3}	---
D = 5.299 in.	2.50	.472	8	54	2.239×10^{-3}	---
X'/D = 4	5.00	.945	13	54	7.047×10^{-4}	---
O/F = 6.0:1	7.50	1.416	18	24	4.139×10^{-4}	---
P ambient = 5.5 Microns	12.36	2.340	25	0	1.289×10^{-4}	---
P combustion = 590.5 psia	17.50	3.310	38	24	Out	---
Engine Type: 2H - 3%	22.45	4.240	41	36	Out	---

*Phase I

Table 48

IBEF 3% General Dynamics Booster/Separation Impingement Test (Volume Definition)

Facility Parameters	R (in.)	R/D	θ (deg.)	t _{min.} (min.)	P _O /P _C	c ₁ (lbm/in. ² -sec.)
X = 21.238 in.	0	0	0	0	3.537 x 10 ⁻³	—
D = 5.298 in.	1.60	.302	5	36	1.747 x 10 ⁻³	—
X/D = 4	3.14	.593	10	50	1.002 x 10 ⁻³	—
C/F = 6.0:1	5.328	1.006	14	55	9.638 x 10 ⁻⁴	—
Ambient = 3.0 microns	7.421	1.401	18	0	6.872 x 10 ⁻⁴	—
P _{combustion} = 596.1 psia	13.645	2.576	31	0	.825 x 10 ⁻⁵	—
Engine Type: 2H - 3%	18.515	3.495	40	20	—	6.8

^{*}Phase 1

Table 49

IBFF 3 rd Generation Dynamics Booster/Separation Impingement Test (Plume Definition)		r_1	r_2	r_{12}
Facility Parameters	R (in.)	r/D	θ (deg)	θ (deg)
X = 52.98 in.	0	0	0	0
D = 5.298 in.	2.65	.50	3	30
X/D = 10	5.30	1.00	6	54
O/F = 6.0;1	7.36	1.39	10	5
P ambient = 3.0 microns	9.25	1.75	12	5
P combustion = 595.3 psia	17.50	3.30	21	0
Engine Type: Equivalent	21.23	4.00	24	0
	23.92	4.50	25	6
				Out

Table 50

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)					
Facility Parameters	R (in.)	R/D	0 (deg)	0 (min.)	P'_o/P_c (1314/ $\text{ft}^2 \cdot \text{sec.}$)
X = 52.93 in.	0	0	0	0	1.393×10^{-4}
D = 5.298 in.	17.500	3.30	21	0	Out
X/D = 10	21.125	3.99	23	48	5.868×10^{-5}
O/F = 6.0:1	23.437	4.40	25	6	4.852×10^{-5}
P _{ambient} = 3.0 microns	26.375	4.98	27	30	2.465×10^{-5}
P _{combustion} = 596.8	29.125	5.50	28	58	1.296×10^{-5}
Engine Type: Equivalent	31.562	5.96	31	36	1.079×10^{-5}
	35.750	6.76	35	0	5.677×10^{-6}

Table 51

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)					
Facility Parameters	R (in.)	R/D	0		q_1 (Btu/ f_t^2 -sec.)
			(deg)	(mic.)	
X = 52.98 in.	0	0	0	0	2.362×10^{-4}
D = 5.298 in.	2.65	.50	3	30	2.381×10^{-4}
X/D = 10	5.30	1.00	6	54	1.927×10^{-4}
O/F = 6.0:1	7.36	1.39	10	5	3.524×10^{-4}
P _{Ambient} = 3.0 microns	9.25	1.75	12	5	8.830×10^{-5}
P _{Combustion} = 536.7 psia	17.50	3.30	21	0	8.289×10^{-5}
Engine Type: Equivalent	21.20	4.00	24	0	2.985×10^{-5}
	23.92	4.50	25	5	2.819×10^{-5}

Table 52

IBFR 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)					
Facility Parameters	R (in.)	R/D	θ (deg)	0 (min.)	P'_o/P_c (Bar/in. ² -gr./cc.)
X = 52.98 in.	0	0	0	0	1.417x10 ⁻⁴
D = 5.298 in.	17.500	3.30	21	0	7.158x10 ⁻⁵
X/D = 10	21.125	3.99	23	48	4.494x10 ⁻⁵
O/F = 6.0:1	23.435	4.40	25	6	2.340x10 ⁻⁵
P _{ambient} = 3.0 Microns	26.375	4.98	27	30	1.888x10 ⁻⁵
P _{combustion} = 598.6 psia	29.125	5.50	28	58	8.002x10 ⁻⁶
Engine Type: Equivalent	31.562	5.96	34	36	8.419x10 ⁻⁶
	35.750	6.76	35	0	4.291x10 ⁻⁶

Table 53

Facility Parameters	R (in.)	R/D	0		P'/P_c	q_1 (Btu/in. ² -sec.)
			(deg)	(min.)		
X = 52.98 in.	0	0	0	0	2.458x10 ⁻⁴	—
D = 5.298 in.	2.65	.50	3	30	2.626x10 ⁻⁴	—
X/D = 10	5.30	1.00	6	54	Out	—
C/F = 6.0:1	7.95	1.50	9	48	1.701x10 ⁻⁴	—
P _{ambient} = 14.7 microns	10.29	1.94	13	30	1.213x10 ⁻⁴	—
P _{combustion} = 708.5 psia	17.45	3.30	21	0	6.447x10 ⁻⁵	—
Engine Type. 2V - 3%	21.17	4.00	23	48	2.959x10 ⁻⁵	—
	23.27	4.40	25	6	1.358x10 ⁻⁵	—

Table 5.4

IBFF 3% General Dynamics Booster/Separation Impingement Test: (Plume Definition)		θ		Q_1	
Facility Parameters	R (in.)	R/D	(deg)	(min.)	P'_0/P_c
			0	0	$(\text{Btu}/\text{ft}^2 \cdot \text{sec})$
X = 52.98 in.	0	0	0	0	2.866×10^{-4}
D = 5.298 in.	17.500	3.30	21	0	Out
X/D = 10	21.125	3.99	23	48	3.402×10^{-5}
Q/F = 6.0:1	23.437	4.40	25	6	1.413×10^{-5}
P ambient = 5.0 Microns	26.375	4.98	27	30	1.458×10^{-5}
P combustion = 682.9 psia	29.125	5.50	28	58	6.298×10^{-6}
Engine Type: 2V - 3%	31.562	5.96	31	36	5.696×10^{-6}
	35.750	6.76	35	0	3.055×10^{-6}

Table 55

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	0 (min.)	P ₀ '/P _C	q (Btu/ft ² - sec.)
X = 52.98 in.	0	0	0	0	1.671x10 ⁻⁴	—
D = 5.298 in.	2.65	.50	3	30	2.475x10 ⁻⁴	—
X/D = 10	5.30	1.00	6	54	2.635x10 ⁻⁴	—
O/F = 6.0:1	7.95	1.50	9	48	1.275x10 ⁻⁴	—
P _{Ambient} = 2.0	10.29	1.94	13	30	1.082x10 ⁻⁴	—
P _{combustion} = 731.7 psia	17.45	3.30	21	0	6.561x10 ⁻⁵	—
Engine Type: 2V - 3%	21.17	4.00	23	48	4.196x10 ⁻⁵	—
	23.27	4.40	25	6	2.351x10 ⁻⁵	—

Table 56

Facility Parameters	R (in.)	R/D	0		P'/P_c	q (Btu/ft ² -sec.)
			(deg)	(min.)		
X = 52.98 in.	0	0	0	0	2.438×10^{-4}	—
D = 5.298 in.	17,500	3.30	21	0	Out	—
X/D = 10	21.125	3.99	23	48	3.482×10^{-5}	—
O/F = 6.0:1	23.437	4.40	25	6	1.418×10^{-5}	—
P _{ambient} = 3.0 Microns	26.375	4.98	27	30	1.111×10^{-5}	—
P _{combustion} = 669.6 psia	29.125	5.50	28	58	4.193×10^{-6}	—
Engine Type: 2V - 3%	31.562	5.96	31	36	5.571×10^{-6}	—
	35.750	6.76	35	0	2.727×10^{-6}	—

LMSC-HREC D225839

Table 57

IBFI: 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	θ (min.)	P _{o'} /P _c	C _c (S ₁₁ /r _c ² - sec)
X = 52.98 in.	0	0	0	0	2.663x10 ⁻⁴	—
D = 5.298 in.	2.65	.50	3	30	2.680x10 ⁻⁴	—
X/D = 10	5.30	1.00	6	50	2.382x10 ⁻⁴	—
O/F = 6.0:1	7.36	1.39	10	5	3.609x10 ⁻⁴	—
F _{ambient} = 5.0 Microns	7.25	1.75	12	5	2.035x10 ⁻⁴	—
P _{combustion} = 618.7 psia	17.50	3.30	21	6	1.259x10 ⁻⁴	—
Engine Type: 2H - 3%	21.23	4.00	24	0	9.102x10 ⁻⁵	—
	23.92	4.50	25	6	5.639x10 ⁻⁵	—

Table 58

IBFF 3rd General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	C		P'_o/P_c	q (Btu/ft ² - sec)
			(deg)	(min.)		
X = 52.98 in.	0	0	0	C	2.006×10^{-4}	—
D = 5.298	17.500	3.30	21	0	Out	—
X/D = 10	21.125	3.99	23	48	6.757×10^{-5}	—
O/F = 6.0:1	23.437	4.40	25	6	3.438×10^{-5}	—
P ambient = 3.2 microns	26.375	4.98	27	30	2.583×10^{-5}	—
P combustion = 675.4 psia	29.125	5.50	28	58	1.539×10^{-5}	—
Engine Type: 2H - 3%	31.562	5.96	31	36	1.739×10^{-5}	—
	35.750	6.76	35	0	Out	—

Table 59

IBF F 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ		P'_o/P_c	q_o (Btu/ft ² -sec.)
			(deg)	(min.)		
X = 52.98 in.	0	0	0	0	2.776×10^{-4}	—
D = 5.298 in.	2.65	.50	3	30	3.019×10^{-4}	—
X/D = 10	5.30	1.00	6	54	2.582×10^{-4}	—
O/F = 6.0:1	7.36	1.39	10	5	Out	—
P _{ambient} = 5.5 Microns	7.25	1.75	12	5	1.749×10^{-4}	—
P _{combustion} = 26.7 psia	17.50	3.30	21	0	8.750×10^{-5}	—
Engine Type: 2H - 3%	21.23	4.00	24	0	5.374×10^{-5}	—
	23.92	4.50	25	6	4.669×10^{-5}	—

Table 60

IBFF 3% General Dynamics Booster/Separation Impingement Test (P ₀ , u ₀ , Location)					
Facility Parameters	R (in.)	R/D	θ (deg)	P ₀ /P _c	U ₀ /U _c
X = 52.98 in.	0	0	0	2.155x10 ⁻⁴	—
D = 5.298 in.	17.500	3.30	21	0	Out
X/D = 10	21.125	3.99	23	48	8.387x10 ⁻⁵
O/F = 6.0:1	23.437	4.40	25	6	5.474x10 ⁻⁵
P _{ambient} = 5.0 Microns	26.375	4.98	27	30	3.671x10 ⁻⁵
P _{combustion} = 682.1 psia	29.125	5.50	28	58	2.127x10 ⁻⁵
Engine Type: 2H - 3%	31.562	5.96	31	36	2.065x10 ⁻⁵
	35.750	6.76	35	0	1.155x10 ⁻⁵

Table 6.1 *

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_0/P_c	q (Btu/ft ² -sec)
X = 63.58 in.	0	0	0	0	—	51.3
D = 5.298 in.	2.7	.5	2	44	1.66×10^{-4}	—
X/D = 12	6.3	1.2	6	33	1.11×10^{-4}	—
O/F = 6.0:1	8.5	1.6	9	10	1.45×10^{-4}	—
P _{Ambient} = 2.0 Microns	14.5	2.7	14	20	1.14×10^{-4}	—
P _{combustion} = 577.2 psia	17.5	3.3	18	3	9.88×10^{-5}	—
Engine Type: Equivalent	21.2	4.0	21	4	4.30×10^{-5}	—
	23.8	4.5	22	56	2.13×10^{-6}	—

* Phase I

Table A-2

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)			
Facility Parameters	R (in.)	R/D	θ (deg)
			0 (min.)
X = 63.58 in.	0	0	0
D = 5.298 in.	2.7	.5	2
X/D = 12	6.3	1.2	6
O/F = 6.0:1	8.5	1.6	9
P _{Ambient} = 7.0 Microns	14.5	2.7	14
P _{combustion} = 656.5 psia	17.5	3.3	18
Engine Type: 2V - 3%	21.2	4.0	21
	23.8	4.5	22

* Phase I

Table 63

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	θ (min.)	P' ₀ /P _C	q (Btu/ft ² ·sec)
X = 63.58 in.	0	0	0	0	1.85 x 10 ⁻⁴	—
D = 5.298 in.	17.50	3.30	18	3	5.35 x 10 ⁻⁵	—
X/D = 12	21.20	4.00	21	4	3.01 x 10 ⁻⁵	—
O/F = 6.0:1	23.80	4.50	22	56	7.63 x 10 ⁻⁷	—
P _{Ambient} = 4.5 Microns	26.40	5.00	24	57	1.12 x 10 ⁻⁵	—
P _{combustion} = 658.4 psia	29.10	5.50	25	40	Out	—
Engine Type: 2V - 3%	31.75	6.00	27	35	5.21 x 10 ⁻⁶	—
	35.75	6.76	29	57	2.18 x 10 ⁻⁶	—

*Phase I

Table 64

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ 'deg)		P'_o/P_c	q (Btu/ft ² -sec)
			0	0		
X = 63.58 in.	0	0	0	0	—	60.3
D = 5.298 in.	2.7	.5	2	44	1.99×10^{-4}	—
X/D = 12	6.3	1.2	6	33	1.51×10^{-4}	—
O/F = 6.0:1	8.5	1.6	9	10	1.64×10^{-4}	—
P _{Ambient} = 2.0 Microns	14.5	2.7	14	20	1.41×10^{-4}	—
P _{combustion} = 620.6 psia	17.5	3.3	18	3	1.12×10^{-4}	—
Engine Type. 2H - 3 %	21.2	4.0	21	4	6.29×10^{-5}	—
	23.8	4.5	22	56	2.02×10^{-6}	—

*Phase I

Table 65:

IBEF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_0/P_c	c_1 (Btu/ft ² ·sec)
X = 79.5 in.	0	0	0	0	—	Out
D = 5.298 in.	2.55	.481	2	6	1.077×10^{-4}	—
X/D = 15	5.20	.981	4	18	1.096×10^{-4}	—
O/F = 6.0:1	7.90	1.491	6	30	9.806×10^{-5}	—
P _{ambient} = 6.8 Microns	10.50	1.982	8	24	1.064×10^{-4}	—
P _{combustion} = 608.8 psia	15.89	2.999	13	12	7.38×10^{-5}	—
Engine Type: Equivalent	18.45	3.482	15	24	7.85×10^{-5}	—
	21.30	4.001	16	36	7.13×10^{-5}	—
	23.79	4.490	18	36	—	29.1

*Phase I

Table 66*

13EF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	0 (deg)	0 (min.)	P _o '/P _c	C ₁ (Btu/ft ² -sec.)
X = 79.5 in.	0	0	0	0	—	41.9
D = 5.298 in.	2.55	.481	2	6	1.100 x 10 ⁻⁴	—
X/D = 15	5.20	.981	4	18	1.161 x 10 ⁻⁴	—
O/F = 6.0:1	7.90	1.491	6	30	1.063 x 10 ⁻⁴	—
P _{ambient} = 6.0 Microns	10.50	1.982	8	24	1.066 x 10 ⁻⁴	—
P _{combustion} = 542.6 psia	15.89	2.999	13	12	9.113 x 10 ⁻⁵	—
Engine Type: Equivalent	18.45	3.482	15	24	8.403 x 10 ⁻⁵	—
	21.30	4.001	16	36	7.625 x 10 ⁻⁵	—
	23.79	4.490	18	36	—	29.8

*Phase I

Table 67*

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)		P'_0/P_c	q (Btu/ft ² -sec)
			θ (deg)	(min.)		
X = 79.5 in.	0	0	0	0	9.61×10^{-5}	—
D = 5.298 in.	2.7	.5	2	1	6.71×10^{-5}	—
X/D = 15	5.3	1.0	4	45	2.80×10^{-5}	—
O/F = 6.0:1	7.9	1.5	6	24	9.86×10^{-5}	—
P _{ambient} = 1.0 Micron	10.6	2.0	8	23	9.21×10^{-5}	—
P _{combustion} = 527.3 psia	18.5	3.5	15	44	8.33×10^{-5}	—
Engine Type: Equivalent	21.2	4.0	16	44	5.52×10^{-5}	—
	23.8	4.5	19	9	2.66×10^{-6}	—

*Phase I

Table 6.8

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	t (min.)	P _o '/P _c	q (Btu/ft ² ·sec)
X = 79.5 in.	0		0	0	1.060x10 ⁻⁴	—
D = 5.298 in.	2.65	.5	2	0	Out	—
X/D = 15	5.30	1.0	4	12	1.229x10 ⁻⁴	—
O/F = 6.0:1	7.95	1.5	6	30	7.296x10 ⁻⁵	—
P _{ambient} = 5.0 Microns	10.60	2.0	8	24	7.379x10 ⁻⁵	—
P _{combustion} = 607.6 psia	18.54	3.5	15	24	6.715x10 ⁻⁵	—
Engine Type: Equivalent	21.20	4.0	16	36	1.271x10 ⁻⁴	—
	23.84	4.5	18	36	6.729x10 ⁻⁵	—

Table 69

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	t (min.)	P_o/P_c	q (Btu/ft ² -sec)
X = 79.5 in.	0	0	0	0	1.034×10^{-4}	—
D = 5.298 in.	18.540	3.50	15	24	4.248×10^{-5}	—
X/D = 15	21.187	4.00	16	36	6.686×10^{-5}	—
O/F = 6.0:1	23.812	4.50	18	36	6.065×10^{-5}	—
P _{ambient} = 3.0 Microns	26.500	5.00	20	54	Out	—
P _{combustion} = 604.3 psia	29.187	5.50	22	24	3.461×10^{-5}	—
Engine Type: Equivalent	31.750	6.00	24	24	2.211×10^{-5}	—
	35.750	6.76	25	30	1.525×10^{-5}	—

Table 70

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ		P'_0/P_c	q (Btu/ft ² ·sec)
			(deg)	(min.)		
X = 79.5 in.	0	0	0	0	9.064x10 ⁻⁵	—
D = 5.298 in.	2.65	.5	2	0	Out	—
X/D = 15	5.30	1.0	4	12	9.571x10 ⁻⁵	—
O/F = 6.0:1	7.95	1.5	6	30	6.666x10 ⁻⁵	—
P _{Ambient} = 10.0 Microns	10.60	2.0	8	24	7.876x10 ⁻⁵	—
P _{combustion} = 604.1 psia	18.54	3.5	15	24	6.942x10 ⁻⁵	—
Engine Type: Equivalent	21.20	4.0	16	36	1.113x10 ⁻⁴	—
	23.84	4.5	18	36	6.801x10 ⁻⁵	—

Table 71

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_o/P_c	q (Btu/ft ² - sec.)
X = 79.5 in.	0	0	0	0	1.005×10^{-4}	—
D = 5.298 in.	18.54	3.50	15	24	4.911×10^{-5}	—
X/D = 15	21.187	4.00	16	36	6.798×10^{-5}	—
O/F = 6.0:1	23.812	4.50	18	36	6.490×10^{-5}	—
P ambient = 3.0	26.500	5.00	20	54	2.918×10^{-5}	—
P combustion = 638.0 psia	29.187	5.50	22	24	4.609×10^{-5}	—
Engine Type: Equivalent	31.750	6.00	24	24	2.563×10^{-5}	—
	35.750	6.76	25	30	1.518×10^{-5}	—

Table 72*
 IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)		P'_o/P_c	q (Btu/ft ² ·sec)
			0	90		
X = 79.5 in.	0	0	0	0	—	52.8
D = 5.298 in.	2.55	.481	2	6	1.172×10^{-4}	—
X/D = 15	5.20	.981	4	18	1.399×10^{-4}	—
O/F = 6.0:1	7.30	1.491	6	30	1.223×10^{-4}	—
P _{ambient} = 5.8 Microns	10.50	1.982	8	24	1.202×10^{-4}	—
P _{combustion} = 534.4 psia	15.89	2.999	13	1	6.970×10^{-5}	—
Engine Type: 2V - 3%	18.45	3.482	15	24	4.631×10^{-5}	—
	21.30	4.001	16	36	4.339×10^{-5}	—
	23.79	4.490	18	36	—	16.2

* Phase I

Table 73 *

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)					
Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_0/P_c
X = 79.5 in.	0	0	0	0	9.61×10^{-5}
D = 5.298 in.	2.7	.5	2	1	6.71×10^{-5}
X/D = 15	5.3	1.0	4	4.5	2.80×10^{-5}
O/F = 6.0:1	7.9	1.5	6	24	9.86×10^{-5}
P _{Ambient} = 1.0 Microns	10.6	2.0	8	23	9.21×10^{-5}
P _{combustion} = 697.4 psia	18.5	3.5	15	44	8.33×10^{-5}
Engine Type: 2V - 3%	21.2	4.0	16	44	5.52×10^{-5}
	23.8	4.5	19	9	2.66×10^{-6}

*Phase I

Table 7-4*

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)		R (in.)	R/D	θ (deg)	(min.)	P'_Q/P_C	q (Btu/ft ² -sec)
Facility Parameters							
X = 79.5 in.		0	0	0	0	1.37×10^{-4}	—
D = 5.298 in.		18.50	3.5	15	32	3.91×10^{-5}	—
X/D = 15		21.20	4.0	16	53	2.33×10^{-5}	—
O/F = 6.0:1		23.80	4.5	19	0	1.33×10^{-6}	—
P ambient = 2.0 Microns		26.40	5.0	20	50	2.48×10^{-5}	—
P combustion = 661.5 psia		29.10	5.5	22	34	1.12×10^{-5}	—
Engine Type: 2V - 3%		31.75	6.0	24	0	1.29×10^{-5}	—
		35.75	6.75	25	35	1.51×10^{-5}	—

*Phase I.

Table 75

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)		R (in.)	R/D	0 (deg)	0 (min.)	P_o/P_c	q (Btu/ft ² -sec)
Facility Parameters							
X = 79.5 in.		0	0	0	0	1.066x10 ⁻⁴	—
D = 5.298 in.		2.65	.5	2	0	1.522x10 ⁻⁴	—
X/D = 15		5.375	1.0	4	12	1.189x10 ⁻⁴	—
O/F = 6.0:1		18.540	3.5	15	24	8.793x10 ⁻⁵	—
P _{ambient} = 5.0 Microns		21.200	4.0	16	36	7.181x10 ⁻⁵	—
P _{combustion} = 757.5 psia		23.840	4.5	18	36	7.099x10 ⁻⁵	—
Engine Type: 2H - 3%		26.450	5.0	20	54	5.205x10 ⁻⁵	—
		29.250	5.5	22	24	2.752x10 ⁻⁵	—

Table 76

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	0 (min.)	P ₀ '/P _c	q (Btu/ft ² -sec)
X = 79.5 in.	0	0	0	0	9.423x10 ⁻⁵	—
D = 5.298 in.	17.500	3.30	21	0	5.923x10 ⁻⁵	—
X/D = 15	21.125	3.99	23	4	7.848x10 ⁻⁵	—
O/F = 6.0:1	23.435	4.40	25	6	7.929x10 ⁻⁵	—
P _{Ambient} = 3.0 Microns	26.375	4.98	27	30	5.135x10 ⁻⁵	—
P _{combustion} = 725.0	29.125	5.50	28	58	5.173x10 ⁻⁵	—
Engine Type: 2H - 3%	31.562	5.96	31	36	3.337x10 ⁻⁵	—
	35.750	6.76	35	0	2.370x10 ⁻⁵	—

Table 77

Facility Parameters	R (in.)	R/D	θ (deg)		P'_o/P_c	q (Btu/ f_1^2 -sec)
			0	90		
X = 79.5 in.	0	0	0	0	9.045x10 ⁻⁵	—
D = 5.298 in.	2.650	.5	2	0	1.221x10 ⁻⁴	—
X/D = 15	5.375	1.0	4	12	1.003x10 ⁻⁴	—
O/F = 6.0:1	18.540	3.5	15	24	8.582x10 ⁻⁵	—
P _{Ambient} = 2.0 Microns	21.200	4.0	16	36	7.846x10 ⁻⁵	—
P _{combustion} = 725.9 psia	23.840	4.5	18	36	7.592x10 ⁻⁵	—
Engine Type: 2H - 3%	26.450	5.0	20	54	6.170x10 ⁻⁵	—
	29.250	5.5	22	24	1.894x10 ⁻⁵	—

Table 78

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ		P'_o/P_c	q (Btu/ft ² -sec)
			(deg)	(min.)		
X = 79.5 in.	0	0	0	0	8.709×10^{-5}	—
D = 5.298 in.	18.540	3.50	15	24	5.344×10^{-5}	—
X/D = 15	21.187	4.00	16	36	7.382×10^{-5}	—
O/F = 6.0:1	23.812	4.50	18	36	5.879×10^{-5}	—
P ambient = 3.0 Microns	26.500	5.00	20	54	3.964×10^{-5}	—
P combustion = 737.9 psia	29.187	5.50	22	24	4.278×10^{-5}	—
Engine Type: 2H - 3%	31.750	6.00	24	24	2.957×10^{-5}	—
	35.750	6.75	25	30	3.117×10^{-5}	—

Table 79*
IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_0/P_c	q (Btu/ft ² -sec)
X = 79.5 in.	0	0	0	0	8.23×10^{-5}	—
D = 5.298 in.	18.50	3.50	15	32	7.60×10^{-5}	—
X/D = 15	21.20	4.00	16	53	4.73×10^{-5}	—
O/F = 6.0:1	23.80	4.50	19	0	2.54×10^{-6}	—
P _{Ambient} = 2.1 Microns	26.40	5.00	20	50	3.61×10^{-5}	—
P _{combustion} = 434.8 psia	29.10	5.50	22	34	4.33×10^{-6}	—
Engine Type: 2H - 3%	31.75	6.00	24	0	1.10×10^{-5}	—
	35.75	6.76	25	35	9.71×10^{-6}	—

*Phase I

Table 80*

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	θ (min.)	P'_o/P_c	q (Btu/ft ² - sec)
X = 79.5 in.	0	0	0	0	—	101.8
D = 5.298 in.	2.55	.481	2	6	1.147×10^{-4}	—
X/D = 15	5.20	.981	4	18	1.468×10^{-4}	—
O/F = 6.0:1	7.90	1.491	6	30	1.352×10^{-4}	—
P _{Ambient} = 5.0 Microns	10.50	1.982	8	24	1.298×10^{-4}	—
P _{combustion} = 567.6 psia	15.89	2.999	13	12	1.129×10^{-4}	—
Engine Type: 2H - 3%	18.45	3.482	15	24	1.054×10^{-4}	—
	21.30	4.001	16	36	9.088×10^{-5}	—
	23.79	4.490	18	36	—	27.3

***Phase I**

Table 81*

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ		P'_o/P_c	q (Btu/ft ² -sec)
			(deg)	(min.)		
X = 79.4 in.	0	0	0	0	—	41.4
D = 5.298 in.	2.7	.5	2	1	5.99×10^{-5}	—
X/D = 15	5.3	1.0	4	45	4.57×10^{-5}	—
O/F = 6.0:1	7.9	1.5	6	24	1.16×10^{-4}	—
P _{Ambient} = 1.0 Microns	10.6	2.0	8	23	1.07×10^{-4}	—
P _{combustion} = 653.3 psia	18.5	3.5	15	44	8.19×10^{-5}	—
Engine Type: 2H - 3%	21.2	4.0	16	44	4.68×10^{-5}	—
	23.8	4.5	19	9	2.25×10^{-6}	—

*Phase I

Table 82 *

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ		P'_o/P_c	q (Btu/ft ² -sec)
			(deg)	(min.)		
X = 79.4 in.	0	0	0	0	—	37.7
D = 5.298 in.	18.50	3.5	15	32	7.29×10^{-5}	—
X/D = 15	21.20	4.0	16	53	4.91×10^{-5}	—
O/F = 6.0:1	23.80	4.5	19	0	2.09×10^{-6}	—
P _{Ambient} = 2.0 Microns	26.40	5.0	20	50	4.98×10^{-5}	—
P _{combustion} = 646.6 psia	29.10	5.5	23	34	1.58×10^{-5}	—
Engine Type: 2H- 3%	31.75	6.0	24	0	3.29×10^{-5}	—
	35.75	6.76	25	35	1.83×10^{-5}	—

* Phase I

Table 83
PLUME IMPACT HEATING RATE SURVEYS

Table No.	X/D	Engine Config.	Run No.	Symbol	P_c (psia)	P_∞ (μHg)
84	4.0	1	6/0*	■	504.0	3.0
85	4.0	2V	5/0*	◆	557.8	5.0
86	4.0	2H	4/0*	●	596.1	3.0
87	10.0	1	11/0	■	532.6	5.5
88	10.0	1	11/1	□	566.5	5.5
89	10.0	1	12/0	□	601.7	5.5
90	10.0	1	13/0	□	629.7	4.0
91	10.0	2V	25/0	◆	718.4	5.0
92	10.0	2V	26/0	◇	684.6	5.5
93	10.0	2H	47/0	●	726.2	5.2
94	10.0	2H	48/0	○	709.3	3.0
95	12.0	1	58/0*	□	577.2	2.0
96	12.0	2H	60/0*	○	620.6	2.0
97	15.0	1	1/5*	□	608.8	6.8
98	15.0	1	1/6*	■	542.6	6.0
99	15.0	1	13/0	□	629.7	4.0
100	15.0	1	52/0*	□	557.3	1.0
101	15.0	1	53/0*	□	566.2	1.0
102	15.0	1	14/0	■	610.7	2.5
103	15.0	2V	2/0*	◆	534.4	5.8
104	15.0	2V	23/0	◇	703.4	4.5
105	15.0	2V	24/0	◇	715.6	4.2
106	15.0	2V	25/0	◇	718.4	5.0

*Phase I

Table 33 (Continued)

PLUME IMPACT HEATING RATE SURVEYS

Table No.	X/D	Engine Config.	Run No.	Symbol	P_c (psia)	P_∞ (μ Hg)
107	15.0	2V	26/0	◆	684.6	5.5
108	15.0	2H	3/1*	●	567.6	5.0
109	15.0	2H	49/0	○	735.7	3.5
110	15.0	2H	50/0	○	719.9	4.5
111	15.0	2H	54/0*	□	653.3	1.0
112	15.0	2H	55/0*	●	646.6	2.0

*Phase I

Table 84 *

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)							
Facility Parameters	R (in.)	R/D	0		P'_o/P_c	G_1 (Etu/ r_c^2 -sec)	
			(deg)	(min.)			
X = 21.238 in.	0	0	0	0	4.505×10^{-3}	—	
D = 5.298 in.	1.60	.302	5	36	3.992×10^{-3}	—	
X/D = 4	3.14	.593	10	50	2.225×10^{-3}	—	
O/F = 6.0:1	5.328	1.006	14	55	7.905×10^{-4}	—	
P _{ambient} = 3.0 Microns	7.421	1.401	18	30	4.379×10^{-4}	—	
P _{combustion} = 504.0 psia	13.645	2.576	31	0	3.625×10^{-5}	—	
Engine Type: Equivalent	18.515	3.495	40	20	—	2.5	

A-88

*Phase I

Table 85 *

IBFF 3% General Dynamics Booster/Separation Impingement Test* (Plume Definition)		R/D	θ (deg.)	P'_o/P_c	q (Btu/it ² -sec.)
Facility Parameters	R (in.)				
X = 21.238 in.	0	0	0	3.038 x 10 ⁻³	—
D = 5.298 in.	1.60	.302	5	2.904 x 10 ⁻³	—
X/D = 4	3.14	.53	10	2.160 x 10 ⁻³	—
O/F = 6.0: ¹	5.328	1.006	14	7.957 x 10 ⁻⁴	—
P _{ambient} = 5.0 Microns	7.421	1.401	18	4.238 x 10 ⁻⁴	—
P _{combustion} = 557.8 psia	13.645	2.576	31	5.205 x 10 ⁻⁵	—
Engine Type: 2V - 3%	18.515	3.495	40	—	4.26

*Phase I

Table 86 *

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	0		P'_o/P_c	q (Btu/ft ² -sec)
			(deg)	(min.)		
X = 21.238 in.	0	0	0	0	3.537×10^{-3}	—
D = 5.298 in.	1.60	.302	5	36	1.747×10^{-3}	—
X/D = 4	3.14	.593	10	50	1.002×10^{-3}	—
O/F = 6.0:1	5.328	1.006	14	55	9.638×10^{-4}	—
P _{air} ent = 3.0 Microns	7.421	1.401	18	30	6.872×10^{-4}	—
P _{combustion} = 596.1 psia	13.645	2.576	31	0	4.825×10^{-5}	—
Engine Type: 2H - 3%	18.515	3.495	40	20	—	6.8

*Phase I

Table 87

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	θ (min.)	P'_0/P_c	q (Btu/ft ² -sec)
X = 52.98 in.	0	0	0	0	—	87.2
D = 5.298 in.	2.65	.50	3	30	—	65.1
X/D = 10	5.30	1.00	6	54	—	62.4
O/F = 6.0:1	7.36	1.39	10	5	—	56.0
P _{ambient} = 5.5 Microns	9.25	1.75	12	5	—	54.6
P _{combustion} = 532.6 psia	17.50	3.30	21	0	—	34.4
Engine Type: Equivalent	21.23	4.00	24	0	—	20.3
	23.92	4.50	25	6	—	14.0

Table 88

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)					
Facility Parameters	R (in.)	R/D	θ (deg)	$t_{min.}$	P'_0/P_c (Btu/ft ² - sec)
X = 52.98 in.	0	0	0	0	—
D = 5.298 in.	2.65	.50	3	30	—
X/D = 10	5.30	1.00	6	54	—
O/F = 6.0:1	7.36	1.39	10	5	—
P _{ambient} = 5.5 Microns	9.25	1.75	12	5	—
P _{combustion} = 566.5 psia	17.50	3.30	21	0	—
Engine Type: Equivalent	21.23	4.00	24	0	—
	23.92	4.50	25	6	—
					64.1
					50.8
					54.5
					60.8
					58.7
					37.6
					21.1
					12.5

Table 89
IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	θ (min.)	P'_o/P_c	q (Btu/ft ² -sec)
X = 52.93 in.	0	0	0	0	—	68.3
D = 5.298 in.	17.500	3.30	21	0	—	36.0
X/D = 10	21.125	3.99	23	48	—	Out
O/F = 6.0:1	23.435	4.40	25	6	—	18.1
P _{ambient} = 5.5 Microns	26.375	4.98	27	30	—	12.0
P _{combustion} = 601.7 psia	29.125	5.50	28	58	—	9.0
Engine Type: Equivalent	31.562	5.96	31	36	—	4.5
	35.750	6.76	35	0	—	4.0

Table 90

IBFF 5% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_o/P_c	q (Btu/ft ² -sec)
X = 52.98 in.	0	0	0	0	—	40.3
D = 5.298 in.	2.65	.50	2	0	—	40.7
X/D = 10	5.27	1.00	4	12	—	40.0
O/F = 6.0:1	7.95	1.50	6	30	—	29.6
P _{ambient} = 4.0 Microns	10.60	2.00	8	24	—	43.7
P _{combustion} = 629.7 psia	18.54	3.50	15	24	—	38.0
Engine Type: Equivalent	21.20	4.00	16	36	—	31.6
	23.84	4.50	18	36	—	26.5

Table 91

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_o/P_c	q (Btu/ft ² - sec)
X = 52.98 in.	0	0	0	0	—	77.0
D = 5.298 in.	2.65	.50	3	30	—	67.0
X/D = 10	5.30	1.00	6	54	—	72.0
O/F = 6.0:1	7.95	1.50	9	48	—	46.0
P _{Ambient} = 5.0 Microns	10.29	1.94	13	30	—	41.0
P _{combustion} = 718.4 psia	17.45	3.30	21	0	—	30.7
Engine Type: 2V - 3%	21.17	4.00	23	48	—	16.5
	23.27	4.40	25	6	—	16.0

Table 92

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ		P'_o/P_c	q (Btu/ft ² -sec)
			(deg)	(min.)		
X = 52.98 in.	0	0	0	0	—	80.6
D = 5.298 in.	17.500	3.30	21	0	—	30.1
X/D = 10	21.125	3.99	23	48	—	Out
O/F = 6.0:1	23.435	4.40	25	6	—	Out
P _{Ambient} = 5.5 Microns	26.375	4.98	27	30	—	Out
P _{combustion} = 634.6 psia	29.125	5.50	28	58	—	Out
Engine Type: 2X - 3%	31.562	5.96	31	36	—	Out
	35.750	6.76	35	0	—	Out

Table 93

LMSC-HREC D225839

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_o/P_c	q (Btu/ft ² -sec)
X = 52.98 in.	0	0	0	0	—	Out
D = 5.298 in.	2.65	.50	3	30	—	73.0
X/D = 10	5.30	1.00	6	54	—	72.3
O/F = 6.0:1	7.36	1.39	10	5	—	48.2
P _{ambient} = 5.2 Microns	9.25	1.75	12	5	—	52.9
P _{combustion} = 726.2 psia	17.50	3.30	21	0	—	34.1
Engine Type: 2H - 3%	21.23	4.00	24	0	—	25.8
	23.92	4.50	25	6	—	20.2

Table 94

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ		P'_o/P_c	q (Btu/ft ² -sec)
			(deg)	(min.)		
X = 52.98 in.	0	0	0	0	—	67.6
D = 5.298 in.	17.500	3.30	21	0	—	38.4
X/D = 10	21.125	3.99	23	48	Out	
O/F = 6.0:1	23.435	4.40	25	6	Out	
P _{ambient} = 3.0 Microns	26.375	4.98	27	30	Out	
P _{combustion} = 709.3 psia	29.125	5.50	28	58	Out	
Engine Type: 2H - 3%	31.562	5.96	31	36	Out	
	35.750	6.76	35	0	Out	

Table 95*

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	θ (min.)	P'_o/P_c	q (Btu/ft ² -sec)
X = 63.58 in.	0	0	0	0	—	51.3
D = 5.298 in.	2.1	.5	2	44	1.66×10^{-4}	—
X/D = 12	6.3	1.2	6	33	1.11×10^{-4}	—
O/F = 6.0:1	8.5	1.6	9	10	1.45×10^{-4}	—
P _{Ambient} = 2.0 Microns	14.5	2.7	14	20	1.14×10^{-4}	—
P _{Combustion} = 577.2 psia	17.5	3.3	18	3	9.88×10^{-5}	—
Engine Type: Equivalent	21.2	4.0	21	4	4.30×10^{-5}	—
	23.8	4.5	22	56	2.13×10^{-6}	—

* Phase I

Table 96 *

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						q (Btu/ft ² -sec)
Facility Parameters	R (in.)	R/D	θ (deg)	θ (min.)	P'_0/P_c	
X = 63.58 in.	0	0	0	0	—	60.3
D = 5.298 in.	2.7	.5	2	44	1.99×10^{-4}	—
X/D = 12	6.3	1.2	6	33	1.31×10^{-4}	—
O/F = 6.0:1	8.5	1.6	9	10	1.64×10^{-4}	—
P ambient = 2.0 Microns	14.5	2.7	14	20	1.41×10^{-4}	—
P combustion = 620.6 psia	17.5	3.3	18	3	1.12×10^{-4}	—
Engine Type: 2H - 3 %	21.2	4.0	21	4	6.29×10^{-5}	—
	23.8	4.5	22	56	2.02×10^{-6}	—

* Phase I

Table 97*

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)		R (in.)	R/D	θ (deg)		P'_o/P_c	Q_o (Btu/ $\text{ft}^2\text{-sec}$)
Facility Parameters	0 (min.)			0	6		
X = 79.5 in.	0	0	.481	2	6	—	Out
D = 5.298 in.	2.55	.481	.981	4	18	1.077×10^{-4}	—
X/D = 15	5.20	.981	1.491	6	30	1.096×10^{-4}	—
O/F = 6.0:1	7.90	1.491	1.982	8	24	9.806×10^{-5}	—
P ambient = 6.8 microns	10.50	1.982	2.999	13	24	1.064×10^{-4}	—
P combustion = 608.8 psia	15.89	2.999	3.482	13	12	7.38×10^{-5}	—
Engine Type: Equivalent	18.45	3.482	4.001	15	24	7.85×10^{-5}	—
	21.30	4.001	4.490	16	36	7.13×10^{-5}	—
	23.79	4.490	—	18	36	—	29.1

*Phase I

Table 98*
IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	P'_o/P_c	q (Btu/ft ² -sec)
X = 79.5 in.	0	0	0	—	41.9
D = 5.208 in.	2.55	.481	2	1.100 x 10 ⁻⁴	—
X/D = 15	5.20	.981	4	1.161 x 10 ⁻⁴	—
O/F = 6.0:1	7.90	1.491	6	1.063 x 10 ⁻⁴	—
P _{Ambient} = 6.0 Microns	10.50	1.982	8	1.066 x 10 ⁻⁴	—
P _{combustion} = 542.6 psia	15.89	2.999	13	9.113 x 10 ⁻⁵	—
Engine Type: Equivalent	18.45	3.482	15	8.403 x 10 ⁻⁵	—
	21.30	4.001	16	7.625 x 10 ⁻⁵	—
	23.79	4.490	18	36	—
					29.8

* Phase I

Table 99

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)		R (in.)	R/D	θ (deg)	(min.)	P'_o/P_c	q (Btu/ ft^2 -sec.)
Facility Parameters							
X = 79.4 in.		0	0	0	0	—	40.3
D = 5.298 in.	.5	2.65	2	0	—	—	40.7
X/D = 15	1.0	5.30	4	12	—	—	49.0
O/F = 6.0:1	1.5	7.95	6	30	—	—	29.6
P _{Ambient} = 4.0 microns	2.0	10.60	8	24	—	—	43.7
P _{combustion} = 629.7 psia	3.5	18.54	15	24	—	—	38.0
Engine Type: Equivalent	4.5	21.20	16	36	—	—	31.6
		23.84	18	36	—	—	26.5

Table 100*

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_o/P_c	q (Btu/ft ² -sec)
X = 79.4 in.	0	0	0	0	—	35.2
D = 5.198 in.	2.00	.5	2	1	—	38.8
X/D = 15	5.00	1.0	4	13	—	46.9
O/F = 6.0:1	7.93	1.5	6	24	—	44.1
P _{Ambient} = 1.0 Microns	10.56	2.0	8	34	—	33.8
P _{combustion} = 557.3 psia	18.51	3.5	15	19	—	36.0
Engine Type: Equivalent	21.18	4.0	16	50	—	31.0
* Phase I	23.80	4.5	18	42	—	24.8
	26.43	5.0	20	58	—	23.9
	29.10	5.5	22	19	—	13.6

Table 101*
IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)		P'_o/P_c	q (Btu/ft ² -sec)
			0	0		
X = 79.4 in.	0	0	0	0	—	37.0
D = 5.298 in.	7.93	1.50	6	24	—	40.2
X/D = 15	10.56	2.00	8	34	—	34.2
O/F = 6.0:1	18.51	3.50	15	19	—	33.8
P ambient = 1.0 Microns	21.18	4.00	16	50	—	31.3
P combustion = 566.2 psia	23.80	4.50	18	42	—	26.0
Engine Type: Equivalent	26.43	5.00	20	58	—	24.6
	29.10	5.50	22	19	—	15.2
	31.75	6.00	24	0	—	17.1
* Phase I	35.75	6.76	25	35	—	11.0

Table 102

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ		P'_o/P_c	q (Btu/ft ² -sec)
			(deg)	(min.)		
X = 79.5 in.	0	0	0	0	—	34.58
D = .298 in.	18.54	3.50	15	24	—	25.50
X/D = 15	21.20	4.00	16	36	—	30.31
O/F = 6.0:1	23.84	4.50	18	36	—	25.18
P _{ambient} = 2.5 Microns	26.45	5.00	20	54	—	21.09
P _{combustion} = 610.7 psia	29.10	5.50	22	24	—	1.3
Engine Type: Equivalent	31.75	6.00	24	24	—	9.74
	35.75	6.76	25	30	—	9.95

Table 103*

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	θ (min.)	P' _o /P _c	q (Btu/ft ² -sec.)
X = 79.5 in.	0	0	0	0	—	52.8
D = 5.298 in.	2.55	.481	2	6	1.172 x 10 ⁻⁴	—
X/D = 15	5.20	.981	4	18	1.399 x 10 ⁻⁴	—
O/F = 6.0:1	7.90	1.491	6	30	1.223 x 10 ⁻⁴	—
P _{ambient} = 5.8 Microns	10.50	1.982	8	24	1.202 x 10 ⁻⁴	—
P _{combustion} = 534.4 psia	15.89	2.999	13	12	6.970 x 10 ⁻⁵	—
Engine Type: 2V - 3%	18.45	3.482	15	24	4.631 x 10 ⁻⁵	—
	21.30	4.001	16	36	4.339 x 10 ⁻⁵	—
	23.79	4.490	18	36	—	16.2

*Phase I

Table 104

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ		P'_o/P_c	q (Btu/ft ² -sec)
			(deg)	(min.)		
X = 79.5 in.	0	0	0	0	—	48.78
D = 5.298 in.	2.65	.5	2	0	—	43.23
X/D = 15	5.30	1.0	4	12	—	49.08
O/F = 6.0:1	18.54	3.5	15	24	—	24.03
P _{Ambient} = 4.5 Microns	21.20	4.0	16	36	—	19.62
P _{combustion} = 703.4 psia	23.84	4.5	18	36	—	15.27
Engine Type: 2V - 3%	26.45	5.0	20	54	—	15.25
	29.10	5.5	22	24	—	13.34

Table 105

Facility Parameters	R (in.)	R/D	θ		P'_o/P_c	q (Btu/ft ² -sec)
			(deg)	(min.)		
X = 79.5 in	0	0	0	0	—	38.00
D = 5.298 in.	18.54	3.50	15	24	—	25.51
X/D = 15	21.20	4.00	16	36	—	20.00
O/F = 6.0:1	23.84	4.50	18	36	—	17.21
P _{Ambient} = 4.2 Microns	26.45	5.00	20	54	—	15.50
P _{combustion} = 715.8 psia	29.10	5.50	22	24	—	18.01
Engine Type: 2V - 3%	31.75	6.00	24	24	—	5.49
	35.75	6.76	25	30	—	2.91

Table 106

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)		R (in.)	R/D	(deg)	θ (min.)	P'_o/P_c	q (Btu/ft ² -sec)
Facility Parameters							
X = 79.5 in.		0	0	0	0	—	77.0
D = 5.298 in.		2.65	.5	2	0	—	55.5
X/D = 15		5.30	1.0	4	12	—	60.0
O/F = 6.0:1		18.54	3.5	15	24	—	38.2
P _{ambient} = 5.0 Microns		21.20	4.0	16	36	—	34.0
P _{combustion} = 718.4 Psia		23.84	4.5	18	36	—	25.0
Engine Type: 2V - 3%		26.45	5.0	20	54	—	13.7
		29.10	5.5	22	24	—	13.3

Table 107

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	P'_o/P_c	q (Btu/ft ² -sec)	
X = 79.5 in.	0	0	0	—	—	80.0
D = 5.298 in.	17.500	3.30	21	0	—	30.1
X/D = 15	21.125	3.99	23	48	—	Out
O/F = 6.0:1	23.437	4.40	25	6	—	Out
P _{ambient} = 5.5 Microns	26.375	4.98	27	30	—	Out
P _{combustion} = 684.6 psia	29.125	5.50	28	58	—	Out
Engine Type: 2V - 3%	31.562	5.96	31	36	—	Out
	35.75	6.76	35	0	—	Out

Table 108

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)	(min.)	P'_o/P_c	q (Btu/ft ² -sec)
X = 79.5 in.	0	0	0	0	—	101.8
D = 5.298 in.	2.55	.481	2	6	1.147×10^{-4}	—
X/D = 15	5.20	.981	4	18	1.468×10^{-4}	—
O/F = 6.0:1	7.90	1.491	6	30	1.352×10^{-4}	—
P _{ambient} = 5.0 Microns	10.50	1.982	8	24	1.298×10^{-4}	—
P _{combustion} = 567.6 psia	15.89	2.999	13	12	1.129×10^{-4}	—
Engine Type: 2H - 3%	18.45	3.482	15	24	1.054×10^{-4}	—
	21.30	4.001	16	36	9.088×10^{-5}	—
	23.79	4.490	18	36	—	27.3

*Phase I

Table 109

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ		P'_o/P_c	q (Btu/ft ² -sec)
			(deg)	(min.)		
X = 79.5 in.	0	0	0	0	—	Out
D = 5.298 in.	2.65	.5	2	0	—	50.7
X/D = 15	5.27	1.0	4	12	—	Out
O/F = 6.0:1	18.54	3.5	15	24	—	38.0
P _{Ambient} = 3.5 Microns	21.20	4.0	16	36	—	39.0
P _{Combustion} = 735.7 psia	23.84	4.5	18	36	—	37.0
Engine Type: 2H - 3%	26.45	5.0	20	54	—	30.0
	29.10	5.5	22	24	—	27.8

Table 110

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)		R (in.)	R/D	0 (deg)	0 (min.)	P'_o/P_c	q (Btu/ft ² - sec)
X = 79.5 in.		0	0	0	0	—	48.00
D = 5.298 in.		18.54	3.50	15	24	—	39.50
X/D = 15		21.20	4.00	16	24	—	38.50
O/F = 6.0:1		23.84	4.50	18	24	—	31.50
P _{ambient} = 4.5 Microns		26.45	5.00	20	54	—	29.00
P _{combustion} = 719.9		29.10	5.50	22	24	—	25.00
Engine Type: 2H - 3%		31.75	6.00	24	24	—	29.28
		35.75	6.76	25	30	—	23.40

Table III*

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)						
Facility Parameters	R (in.)	R/D	θ (deg)		P'_o/P_c	q (Btu/ft ² -sec)
			0	90		
X = 79.5 in.	0	0	0	0	—	41.4
D = 5.298 in.	2.7	.5	2	1	5.99×10^{-5}	—
X/D = 15	5.3	1.0	4	45	4.57×10^{-5}	—
O/F = 6.0:1	7.9	1.5	6	24	1.16×10^{-4}	—
P _{ambient} = 1.0 Microns	10.6	2.0	8	23	1.07×10^{-4}	—
P _{combustion} = 653.3 psia	18.5	3.5	15	44	8.19×10^{-5}	—
Engine Type: 2H - 3%	21.2	4.0	16	44	4.68×10^{-5}	—
	23.8	4.5	19	9	2.25×10^{-6}	—

*Phase I

Table 112*

IBFF 3% General Dynamics Booster/Separation Impingement Test (Plume Definition)

Facility Parameters	R (in.)	R/D	θ (deg)	P'_o/P_c	q (Btu/ft ² -sec)
X = 79.5 in.	0	0	0	—	37.7
D = 5.298 in.	18.50	3.5	15	7.29×10^{-5}	—
X/D = 15	21.20	4.0	16	4.91×10^{-5}	—
O/F = 6.0:1	23.80	4.5	19	2.09×10^{-6}	—
P _{ambient} = 2.0 Microns	26.40	5.0	20	4.98×10^{-5}	—
P _{combustion} = 646.6 psia	29.10	5.5	23	1.58×10^{-5}	—
Engine Type: 2H- 3%	31.75	6.0	24	3.29×10^{-5}	—
	35.75	6.76	25	1.83×10^{-5}	—

*Phase I

Table 113
BOOSTER IMPINGEMENT TEST CONDITIONS

Table No.	Test Position	Engine Config.	Run No.	Symbol	X (in.)	Y (in.)	α (deg.)	P_c (psia)	P_∞ (μ Hg)
114	2	1	10/0	□	-3.297	4.644	0	671.8	3.0
115	2	1	11/0	□			0	633.1	2.5
116	2	1	13/0	■			0	644.1	2.0
117	2	1	59/0	□			0	563.6	5.4
118	2	1	60/0	□	-3.297	4.644	0	577.5	5.0
119	2	2H	14/1	●			0	669.4	3.0
120	2	2H	15/0	○			0	611.3	2.0
121	2	2H	17/1	-○	-3.297	4.644	0	670.0	2.0
122	4	1	45/0	■	-18.390	6.966	0	707.2	2.0
123	5	1	40/0	■	-6.780	6.966	0	735.7	2.0
124	5	1	41/0	□			0	681.4	1.5
125	5	1	42/0	□			0	705.5	9.0
126	5	1	87/0	□			0	580.9	3.8
127	5	1	88/0	■			0	592.7	4.8
128	5	2H	18/1	○			0	671.8	3.0
129	5	2H	19/0	○			0	679.7	6.0
130	5	2H	20/0	○	-6.780	6.966	0	612.4	6.0
131	8	2H	31/1	■	-6.780	6.966	5	679.7	2.5
132	8	2H	32/0	□	-6.780	6.966	5	669.2	2.0
133	8	2H	33/0	□	-6.780	6.966	5	692.1	2.0

Table 113 (Continued)

Table No.	Test Position	Engine Config.	Run No.	Symbol	X (in)	Y (in.)	α deg.	P_c (psia)	P_∞ (μ Hg)
134	11	2H	29/0	◐	-11.424	14.513	4	657.1	4.0
135	11	2H	30/0	□	-11.424	14.513	4	710.5	4.0
136	14	1	43/1	□-	-11.424	14.513	0	733.5	1.8
137	14	1	44/1	□	-11.424	14.513	0	514.9	2.0
138	14	2H	21/1	○	-11.424	14.513	0	709.9	2.0
139	14	2H	22/0	●	-11.424	14.513	0	632.6	10.0
140	15	1	27/0	-□	.186	14.513	0	731.6	3.0
141	15	1	27/1	■			0	606.0	1.8
142	15	1	28/0	■			0	671.5	3.3
143	15	1	28/1	□			0	546.4	1.4
144	15	1	96/0	■			0	515.0	5.5
145	15	1	96/1	□	.186	14.513	0	626.1	4.0
146	15*	1	55/0	□	.186	14.938	0	626.3	5.5
147	15*	1	56/1	□	.186	14.938	0	612.5	4.0
148	15	2H	80/1	○	.186	14.938	0	677.0	5.0
149	15*	2H	81/1	●	.186	14.938	0	749.4	3.0
150	15	2H	25/0	○	.186	14.513	0	708.7	3.0
151	15	2H	26/0	○	.186	14.513	0	697.6	3.0
152	17	1	79/0	□	-6.780	23.220	0	589.5	3.0
153	17	1	79/1	■			0	586.9	3.0
154	17	2H	23/1	○			0	597.4	3.0
155	17	2H	24/0	○			0	560.0	4.0
156	17	2H	78/0	●			0	741.4	4.0
157	17	2H	78/1	●			0	70 ² 7	4.0
158	17	2V	63/0	◆			0	698.6	5.0
159	17	2V	64/0	◇	-6.780	23.220	0	720.6	5.0

*See each table for explanation

Table 113 (Concluded)

Table No.	Test Position	Engine Config.	Run No.	Symbol	X (in.)	X (in.)	α (deg.)	P_c (psia)	P_∞ (μ Hg)
160	29	1	95/0	□	-6.780	23.220	5	596.8	5.5
161	29	1	95/1	□			5	607.9	5.0
162	29	2H	34/0	□			5	679.2	2.0
163	29	2H	35/1	□			5	626.6	2.0
164	29	2H	94/0	□			5	712.4	5.0
165	29	2H	94/1	□			5	686.0	5.0
166	29	2V	93/0	□			5	716.0	5.5
167	29	2V	93/1	□	-6.780	23.220	5	710.4	4.4
168	30	1	84/0	■	-1.180	23.220	0	576.7	3.0
169	30	1	84/1	□			0	636.9	4.5
170	30	1	37/0	□			0	573.3	2.0
171	30	2H	36/0	○			0	685.2	2.0
172	30	2H	97/0	●			0	800.4	4.0
173	30	2H	97/1	●			0	625.7	5.5
174	30	2V	83/0	◇			0	700.4	5.5
175	30	2V	83/1	◆	-1.180	23.220	0	642.3	3.0
176	31	1	39/0	□	-8.424	14.513	0	487.5	2.0
177	31	1	86/0	■			0	539.9	5.2
178	31	1	86/1	□			0	570.0	3.5
179	31	2H	38/0	○	-8.424	14.513	0	682.6	2.0

Table 114
Test Pt. 2, Run 10/0, Equivalent Engine Conf.

Sensor Number	Fuselage	P_x psia	\dot{q}_x Btu/ft ² sec
1	.0002	—	
2	Out	—	
3	.0023	—	
4	.0033	—	
10	Out	—	
11	.0002	—	
12	.0042	—	

Sensor Number	Tail	P_x psia	\dot{q}_x Btu/ft ² sec
60	1.7979	—	
61	—	Out	
66	—	Out	
67	1.2806	—	
72	—	355.89	
73	—	Out	
77	.2664	—	
78	—	209.77	
79	.0890	—	
85	—	20.32	
87	.1136	—	
88	.0141	—	
89	—	Out	
95	—	8.55	
96	.0454	—	
97	—	92.04	
98	Out	—	
99	—	2.54	

Sensor Number	Wing	P_x psia	\dot{q}_x Btu/ft ² sec
None	None	None	None

Table 115
Test Pt. 2, Run 11/0, Equivalent Engine Conf.

Sensor Number	P _x psia	\dot{q}_x Btu/ft ² sec	Fuselage		
5	.0022	—			
9	.0347	—			
14	—	9.64			
15	—	3.74			
16	—	2.06			
17	—	.35			
19	.0655	—			
20	.0569	—			
21	.0208	—			
22	.0037	—			
24	—	10.45			
25	.0725	—			
26	.0595	—			
27	.0328	—			
28	.0003	—			
29	.0003	—			
30	—	9.02			
33	.0538	—			
34	.0595	—			
35	.0073	—			
36	.0075	—			
39	—	6.83			
40	—	1.46			
53	—	6.59			
62	—	6.12			

Table 116
Test Pt. 2, Run 13/0, Equivalent Engine Conf.

Sensor Number	P _x psia	\dot{q}_1 Btu/ft ² sec	Fuselage
6	—	.762	Tail
7	—	.252	
14	—	6.69	
15	—	5.45	
16	—	1.78	
18	—	.194	
24	—	9.43	
30	—	7.78	
47	.0477	—	
48	.0384	—	
49	.0198	—	
50	.0055	—	
53	—	6.14	
55	.0308	—	
56	.0171	—	
57	.0061	—	
68	.0573	—	
69	.0180	—	
70	Out	—	
80	.0368	—	
81	.0006	—	
82	.0052	—	
90	.0090	—	
91	.0247	—	

Sensor Number	P _x psia	\dot{q}_1 Btu/ft ² sec	Tail
6	—	100	
7	—	—	
14	—	1.51	
15	—	—	
16	—	—	
18	—	—	
24	—	—	
30	—	—	
47	—	—	
48	—	—	
49	—	—	
50	—	—	
53	—	—	
55	—	—	
56	—	—	
57	—	—	
68	—	—	
69	—	—	
70	—	—	
80	—	—	
81	—	—	
82	—	—	
90	—	—	
91	—	—	

Table 117
Test Pt. 2, Run 59/0, Equivalent Engine Conf.

Fuselage				Tail				Wing			
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
6	—	1.20	60	1.15356	—	None	None	None	None	None	None
9	.03753	—	67	.92717	—						
14	—	Out	77	.40927	—						
15	—	4.31	78	—	142.00						
16	—	7.55	79	.08183	—						
17	—	7.54	85	—	11.51						
19	.07880	—	87	.14030	—						
20	.04964	—	88	.03694	—						
21	.00726	—	89	—	63.89						
22	.00243	—	95	—	3.23						
24	—	19.79	96	.03997	—						
25	.07256	—	97	—	Out						
26	.04842	—	100	—	.68						
27	.06300	—									
30	—	15.82									
33	.05698	—									
34	Out	—									
35	Out	—									
36	.01703	—									
39	—	12.08									
47	Out	—									
48	.03397	—									
49	.04551	—									
50	.02027	—									

Table 117 (Continued)
Test Pt. 2, Run 59/0, Equivalent Engine Conf.

Sensor Number	Fuselage	P_x psia	\dot{q} Btu/ft ² sec
53	—	—	11.87
55	.04990	—	—
56	Out	—	—
57	.01481	—	—
62	—	—	12.88
68	.01691	—	—
69	.04428	—	—
70	Out	—	—
80	.00320	—	—
82	.03009	—	—
90	.00440	—	—
91	.02608	—	—

Sensor Number	Tail	P_x psia	\dot{q} Btu/ft ² sec
None	None	None	None

Sensor Number	Wing	P_x psia	\dot{q} Btu/ft ² sec
None	None	None	None

Table 118
Test Pt. 2, Run 60/0, Equivalent Engine Conf.

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
6	—	1.23
9	.03425	—
14	—	1.54
15	—	5.60
16	—	7.46
17	—	7.46
19	.07477	—
20	.04786	—
21	Out	—
22	.00220	—
24	—	16.73
25	.07058	—
26	.05003	—
27	.05865	—
30	—	14.80
33	.06052	—
34	.04546	—
35	Out	—
36	.01805	—
39	—	72.97
47	.06723	—
48	.03155	—
49	.04378	—
50	.02090	—

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
60	.99438	—
67	1.01662	—
77	.43389	—
78	—	142.58
79	.08488	—
85	—	10.30
87	.15794	—
88	.03553	—
89	—	74.55
95	—	44.53
96	.04160	—
97	—	30.26
100	—	1.57

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
None	None	None

Table 118 (Continued)
Test Pt. 2. Run 60/0. Equivalent Engine Conf.

Fuselage			
Sensor Number	P _x psia	q̄ Btu/ft ² sec ⁻¹	
53	—	12.16	
55	Out	—	
56	Out	—	
57	Out	—	
62	—	12.23	
68	.01614	—	
69	.03397	—	
70	Out	—	
80	Out	—	
82	.02436	—	
90	.00579	—	
91	Out	—	

Tail			
Sensor Number	P _X psia	q Btu/ft ² sec	

Wing			
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	
None	None	None	

Table 119
Test Pt. 2, Run 14/1, Horizontal Two-Engine Conf.

Sensor Number	P _x psia	q̇ Btu/ft ² sec	Fuselage
1	.0001	—	
2	.0000	—	
3	.0010	—	
4	.0016	—	
10	Out	—	
11	.0002	—	
12	.0016	—	

Sensor Number	P _x psia	q̇ Btu/ft ² sec	Tail
60	.11286	—	
61	—	Out	
66	—	Out	
67	1.4920	—	
72	—	Out	
73	—	Out	
77	.4085	—	
78	—	Out	
79	.1133	—	
85	—	11.20	
87	.1088	—	
88	.0140	—	
89	—	60.06	
95	—	4.81	
96	.0426	—	
97	—	27.33	
98	Out	—	
99	—	1.54	

Sensor Number	P _x psia	q̇ Btu/ft ² sec	Wing
None	None	None	None

LMSC-HREC D225839 .

Table 120
Test Pt. 2. Run 15/0. Horizontal Two-Engine Conf.

Fuselage			
Sensor Number	P _x psia	dot q Btu/ft ² sec	
5	.0000	—	
9	.0276	—	
14	—	6.65	
15	—	1.54	
16	—	1.21	
17	—	Out	
19	.0643	—	
20	.0250	—	
21	.0164	—	
22	.0037	—	
24	—	7.96	
25	.0852	—	
26	.0358	—	
27	.0256	—	
28	.0001	—	
29	.0004	—	
30	—	7.76	
33	.0745	—	
34	.0365	—	
35	.0064	—	
36	.0083	—	
39	—	6.67	
40	—	1.30	
53	—	5.16	
62	—	6.18	

Table 120 Test Pt. 2, Run 15/0, Horizontal Two-End

Tail	P_x psia	\dot{q} Btu/ ft^2 sec
Sensor Number	None	None
None		

Table 120
Test Pt. 2, Run 15/0, Horizontal Two-Engine Conf.

Wing				
Sensor Number	P _x psia	i D _{1.4} /f _{1.2} sec		
None	None	None		

Table 121
Test Pt. 2, Run 17/1, Horizontal Two-Engine Conf.

Fuselage		Tail		Wing	
Sensor Number	P _x psia	Sensor Number	P _x psia	Sensor Number	P _x psia
6	—	2.42	100	—	—
7	—	.301	—	—	—
14	—	6.44	—	—	—
15	—	1.91	—	—	—
16	—	1.26	—	—	—
18	—	.087	—	—	—
24	—	9.03	—	—	—
30	—	9.01	—	—	—
47	.0791	—	—	—	—
48	.0392	—	—	—	—
49	.0255	—	—	—	—
50	Out	—	—	—	—
53	—	5.63	—	—	—
55	.0457	—	—	—	—
56	.0205	—	—	—	—
57	.0102	—	—	—	—
68	.1150	—	—	—	—
69	.0230	—	—	—	—
70	.0065	—	—	—	—
80	.0539	—	—	—	—
81	Out	—	—	—	—
82	.0083	—	—	—	—
90	.0113	—	—	—	—
91	.0451	—	—	—	—

Table 122
Test Pt. 4, Run 45/0, Equivalent Engine Conf.

Fuselage		Tail		Wing	
Sensor Number	P_x^s psia	\dot{q} Btu/ft ² sec	Sensor Number	P_x^s psia	\dot{q} Btu/ft ² sec
68	.0137	—	66	—	Out
69	.0100	—	67	2.085	—
80	.0207	—	72	—	Out
81	.0320	—	73	—	Out
82	.0063	—	77	5.198	—
84	Out	—	78	—	Out
90	.0253	—	79	.5024	—
91	Out	—	85	—	1.71
92	.0002	—	87	.5513	—
93	—	—	88	.3099	—
			89	—	Out
			95	—	.752
			96	.0328	—
			97	—	.530
			99	—	.258
			100	—	.170

Table 123
Test Pt. 5, Run 40/0, Equivalent Engine Conf.

Sensor Number	P_x psia	\dot{q} Btu/ $ft^2 sec$
68	.0279	—
69	.0193	—
70	.0061	—
80	.0377	—
81	.0104	—
82	.0085	—

Sensor Number	P_x psia	\dot{q} Btu/ $ft^2 sec$
60	.2917	—
61	—	Out
66	—	Out
67	.9326	—
72	—	Out
73	—	Out
77	1.3436	—
78	—	Out
79	.1766	—
85	—	17.13
87	.2994	—
88	.0687	—
89	—	Out
95	—	6.53
96	.0995	—
97	—	6.30
98	.0005	—
99	—	2.04
100	—	2.11

Wing	
Sensor Number	P_x psia
None	None

Table 124
Test Pt. 5, Run 41/0, Equivalent Engine Conf.

Fuselage			Tail			Wing		
Sensor Number	P _x psia	q̄ Btu/ft ² sec	Sensor Number	P _x psia	q̄ Btu/ft ² sec	Sensor Number	P _x psia	q̄ Btu/ft ² sec
15	—	.373	60	.3145	—	None	None	None
16	—	.401	67	.9572	—			
18	—	.557	77	1.4656	—			
25	.0203	—	79	.1476	—			
33	.0297	—	87	.3302	—			
34	.0011	—	96	.1064	—			
39	—	5.71						
40	—	.949						
47	.0417	—						
48	.0472	—						
49	.0006	—						
55	.0448	—						
62	—	9.16						
63	—	1.54						
64	—	.234						
68	.0291	—						
74	—	7.74						
75	—	1.07						
80	—	.0416						

Table 125
Test Pt. 5, Run 42/0, Equivalent Engine Conf.

Sensor Number	P_x psia	\dot{q} Btu/ ft^2 sec
14	—	.417
24	—	1.31
25	.0226	—
26	.0078	—
30	—	4.84
33	.0262	—
34	.0230	—
35	.0189	—
36	.0021	—
37	.0012	—
47	.0381	—
48	.0423	—
49	.0009	—
50	.0032	—
51	Out	—
53	—	6.71
55	.0416	—
56	.0150	—
57	.0042	—

Sensor Number	P_x psia	\dot{q} Btu/ ft^2 sec
None	None	None

Sensor Number	P_x psia	\dot{q} Btu/ ft^2 sec
None	None	None

Sensor Number	P_x psia	\dot{q} Btu/ ft^2 sec
32	—	.341
38	—	.285
41	—	.14
42	—	.174
43	—	.215
44	—	.409

Table 126
Test Pt. 5, Run 87/0, Equivalent Engine Conf.

Fuselage			Tail			Wing		
Sensor Number	P _x psia	q̄ Btu/ft ² sec	Sensor Number	P _x psia	q̄ Btu/ft ² sec	Sensor Number	P _x psia	q̄ Btu/ft ² sec
19	.00483	—	60	.18743	—	None	None	None
20	.00611	—	67	1.05928	—			
21	.00269	—	77	.90472	—			
25	.01719	—	79	.16038	—			
26	Out	—	85	—	15.95			
27	.00515	—	87	.72619	—			
28	.00154	—	88	.09621	—			
29	Out	—	89	—	198.47			
30	—	Out	95	—	4.37			
33	.03204	—	96	.06891	—			
34	.02632	—	97	—	Out			
35	Out	—	99	—	1.96			
36	.00285	—	100	—	.63			
37	.00670	—	5.18					
39	—	—	.67					
40	—	—						
47	.05045	—						
48	.02751	—						
50	.00524	—						
51	.00004	—						
53	—	—	1.03					
55	.02256	—						
56	.01212	—						

Table 126 (Continued)
Test Pt. 5, Run 87/0, Equivalent Engine Conf.

Fuselage		Tail		Wing	
Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	Sensor Number	P_x psia	\dot{q} Btu/ft ² sec
57	Out	—	None	None	None
58	Out	—	None	None	None
62	—	7.01			
63	—	4.73			
64	—	6.45			
68	.03911	—			
69	.02537	—			
70	.00323	—			
71	Out	—			
74	—	Out			
75	—	Out			
80	.02067	—			
81	Out	—			
82	.00412	—			
83	.00300	—			
90	.02066	—			
91	.04379	—			

Table 127
Test Pt. 5, Run 88/0, Equivalent Engine Conf.

Fuselage				Tail				Wing			
Sensor Number	P _x psia	q̄	Btu/ft ² sec	Sensor Number	P _x psia	q̄	Btu/ft ² sec	Sensor Number	P _x psia	q̄	Btu/ft ² sec
19	.00475	—		60	.21485	—		None	None	None	
20	.00439	—		67	.98535	—					
21	.00353	—		77	.96195	—					
25	.01438	—		79	.17262	—					
26	.00452	—		85	—	15.17					
27	.00367	—		87	.38200	—					
28	.00081	—		88	.09925	—					
29	Out	—		89	—	Out					
30	—	18.00		95	—	4.50					
33	.03215	—		96	.06813	—					
34	.02715	—		97	—	Out					
35	.00605	—		99	—	2.13					
36	.00126	—		100	—	.84					
37	Out	—									
39	—	5.65									
40	—	Out									
47	.04578	—									
48	.02935	—									
50	.00545	—									
51	.00886	—									
53	—	15.07									
55	.02419	—									
56	.01470	—									

Table 127 (Continued)
Test Pt. 5, Run 88/0, Equivalent Engine Conf.

LMSC-HREC D225839

Fuselage		Tail			Wing		
Sensor Number	P _x psia	q̄	Btu/ft ² sec	Sensor Number	P _x psia	q̄	Btu/ft ² sec
57	.00394	—	—	None	None	None	None
58	Out	—	—				
62	—	8.32	—				
63	—	Out	—				
64	—	9.76	—				
68	.03532	—	—				
69	.01955	—	—				
70	Out	—	—				
71	Out	—	—				
74	—	20.07	—				
75	—	10.36	—				
80	.01906	—	—				
81	.01220	—	—				
82	.00471	—	—				
83	.00384	—	—				
90	.01837	—	—				
91	.04721	—	—				

Table 128
Test Pt. 5, Run 18/1, Horizontal Two-Engine Conf.

Fuselage		Tail		
Sensor Number	P _x psia	\dot{c}_1 Btu/ $\text{ft}^2 \text{sec}$	Sensor Number	P _x psia
68	.0603	—	60	.2420
69	Out	—	61	—
70	.0064	—	66	—
80	.0358	—	67	.8393
81	.0294	—	72	—
82	Out	—	73	—
			77	1.2123
			78	—
			79	.2685
			85	—
			87	.3946
			88	.0280
			89	—
			95	—
			96	.1040
			97	—
			98	Out
			99	—

Fuselage		Tail		
Sensor Number	P _x psia	\dot{c}_1 Btu/ $\text{ft}^2 \text{sec}$	Sensor Number	P _x psia
68	.0603	—	60	.2420
69	Out	—	61	—
70	.0064	—	66	—
80	.0358	—	67	.8393
81	.0294	—	72	—
82	Out	—	73	—
			77	1.2123
			78	—
			79	.2685
			85	—
			87	.3946
			88	.0280
			89	—
			95	—
			96	.1040
			97	—
			98	Out
			99	—

Test Pt. 5, Run 19/0, Horizontal Two-Engine Conf.
Table 129

Fuselage		P_x psia	\dot{c} Btu/ m^2 sec
Sensor Number			
15	—	—	.33
16	—	—	.228
18	—	—	.438
25	.0403	—	—
33	.0511	—	—
34	.0376	—	—
39	—	—	7.90
40	—	—	1.450
47	.0430	—	—
48	.0361	Out	—
49	—	—	—
55	.0423	—	—
62	—	—	19.59
63	—	—	1.71
64	—	—	Out
68	.0579	—	—
74	—	—	.88
75	—	—	1.930
80	.0343	—	—

Tail	Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
	60	.1497	—
	67	.9160	—
	77	1.3567	—
	79	.1956	—
	87	.3653	—
	96	.1153	—

Wing			
Sensor Number	P _x psia	$\dot{Q}_{\text{in}}^{\text{2}}$ Btu/sec	
None	None	None	

Table 130
Test Pt. 5, Run 20/0, Horizontal Two-Engine Conf.

Fuseage			
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	
14	—	.710	
24	—	2.11	
25	.0230	—	
26	.0084	—	
30	—	.460	
33	.0351	—	
34	.0215	—	
35	.0063	—	
36	.0010	—	
37	.0001	—	
47	.0339	—	
48	.0293	—	
49	.0114	—	
50	.0002	—	
51	.0003	—	
53	—	7.08	
55	.0353	—	
56	.0054	—	
57	.0018	—	

Tail			
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	
None	None	None	

Wing			
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	
32	—	—	Oui
38	—	—	.080
41	—	—	.000
42	—	—	.050
43	—	—	.050
44	—	—	.000

LMSC-HREC D225839

Table 131
Test Pt. 8, Run 31/1, Horizontal Two-Engine Conf.

Fuselage				Tail				Wing			
Sensor Number	P _x Psia	q̄ Btu/ft ² sec		Sensor Number	P _x Psia	q̄ Btu/ft ² sec		Sensor Number	P _x Psia	q̄ Btu/ft ² sec	
68	.0933	—		60	.5676	—		None	None	None	
69	.0296	—		61	—	Out					
70	.0202	—		66	—	Out					
80	.0830	—		67	1.903	—					
81	.0632	—		72	—	Out					
82	.0157	—		73	—	Out					
				77	.3957	—					
				78	—	Out					
				79	,1409	—					
				85	—	12.64					
				87	.1719	—					
				88	.0021	—					
				89	—	Out					
				95	—	6.08					
				96	.0320	—					
				97	—	25.20					
				98	Out	—					
				99	—	1.95					
				100	—	1.80					

Table 132
Test Pt. 8, Run 32/0, Horizontal Two-Engine Conf.

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	usage
15	—	.011	
16	—	.151	
18	—	.074	
25	.0531	—	
33	.1040	—	
34	.0252	—	
39	—	5.43	
40	—	1.34	
47	.1026	—	
48	.0332	—	
49	.0002	—	
55	.0714	—	
62	—	1.44	
63	—	1.79	
64	—	.375	
68	.0746	—	
74	—	11.13	
75	—	1.92	
80	.0788	—	

Tail			
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Wing
60	.5237	—	
67	1.5410	—	
77	.2782	—	
79	.1203	—	
87	.1552	—	
96	.0250	—	

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Wing
None	None	None	None

Table 133
Test Pt. 8, Run 33/0, Horizontal Two-Engine Conf.

Sensor Number	P_x Psia	\dot{q} Btu/ft ² sec	Zuselage
14	—	.00	
24	—	4.30	
25	.0571	—	
26	.0137	—	
30	—	9.05	
33	.1108	—	
34	.0258	—	
35	.0163	—	
36	Out	—	
37	.0008	—	
47	.0974	—	
48	.0345	—	
49	Out	—	
50	.0020	—	
51	Out	—	
53	—	8.47	
55	.0831	—	
56	.0339	—	
57	.0093	—	

Sensor Number	P_x Psia	\dot{q} Btu/ft ² sec	Tail
None	None	None	

Sensor Number	P_x Psia	\dot{q} Btu/ft ² sec	Wing
32	—	—	.08
38	—	—	.03
41	—	—	.01
42	—	—	.06
43	—	—	.08
44	—	—	.18

Table 134
Test Pt.11, Run 29/0, Horizontal Two-Engine Conf.

Fuselage Sensor Number	P _x psia	q̄ Btu/ft ² sec	
68	Out	—	
80	.00660	—	
81	Out	—	
82	.0023	—	
90	.0041	—	
91	.01118	—	
92	.0063	—	
93	.0002	—	

Tail			
Sensor Number	P _x psia	q̄ Btu/ft ² sec	
60	Out	—	
61	—	11.35	
66	—	25.43	
67	.0645	—	
72	—	38.22	
73	—	Out	
77	.3050	—	
78	—	Out	
79	.0922	—	
85	—	11.30	
87	.8743	—	
88	.0008	—	
89	—	Out	
95	—	5,12	
96	Out	—	
97	—	Out	
99	—	1.32	

LMSC-HREC D225839

Table 135
Test Pt. 11, Run 30/0, Horizontal Two-Engine Conf.

Sensor Number	P_x psia	\dot{q}_i Btu/ft ² sec	Fuselage
53	—	—	
56	.0005	—	
57	.0003	—	
58	.0002	—	
62	—	5.12	
63	—	.467	
64	—	.422	
65	.0107	—	
69	.0002	—	
0	Out	—	
71	.0001	—	
74	—	.652	
75	—	.693	
80	.0076	—	
81	.0160	—	
82	.0029	—	
83	Out	—	
90	.0051	Out	
91	Out	—	
92	Out	—	
93	.0003	—	

Sensor Number	P_x psia	\dot{q}_i Btu/ft ² sec	Tail
78	—	—	
89	—	—	Out
97	—	—	Out
100	—	—	Out 3.084

Sensor Number	P_x psia	\dot{q}_i Btu/ft ² sec	Wing
None	None	None	None

Table 136
Test Pt. 14, Run 43/1, Equivalent Engine Conf.

Fuselage		Tail		Wing	
Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	Sensor Number	P_x psia	\dot{q} Btu/ft ² sec
68	.0025	—	60	Out	—
80	.0021	—	61	—	4.43
81	.0073	—	66	—	25.26
82	.0018	—	67	.0372	—
90	.0023	—	72	—	33.30
91	.0042	—	73	—	—
92	.0038	—	77	.2001	—
93	.0001	—	78	—	Out
			79	.0339	—
			85	—	7.35
			87	.8280	—
			88	.0223	—
			89	—	Out
			95	—	2.60
			96	1.7283	—
			97	—	Out
			99	—	1.03

Table 137
Test Pt. 14, Run 44/1, Equivalent Engine Conf.

Fuselage		Tail		Wing	
Sensor Number	P _x psia	q̄ Btu/ft ² sec	Sensor Number	P _x psia	q̄ Btu/ft ² sec
53	—	.333	78	—	Out
56	.0002	—	89	—	Out
57	.0003	—	97	—	Out
58	.0001	—	100	—	.894
62	—	.558			
63	—	.171			
64	—	.041			
68	Out	—			
69	.0012	—			
70	.0006	—			
71	Out	—			
74	—	.485			
75	—	.285			
80	.0014	—			
81	.0021	—			
82	.0012	—			
83	.0001	—			
90	.0016	—			
91	.0028	—			
92	.0021	—			
93	.0001	—			

LMSC - HREC D225839

Table 138
Test Pt. 14. Run 2₁/1, Horizontal Two-Engine Conf.

Fuselage			
Sensor Number	P _x psia	q̇ Btu/ft ² sec	
68	Out	—	—
80	.0043	—	—
81	.0001	—	—
82	Out	—	—
90	Out	—	—
91	Out	—	—
92	Cut	—	—
93	Out	—	—

Tail	Sensor Number	P _x psia	\dot{q} Btu/in ² sec
	60	Out	—
	61	—	8.22
	66	—	14.27
	67	.0398	—
	72	—	25.52
	73	—	Out
	77	.0140	—
	78	—	Out
	79	.0437	—
	85	—	6.76
	87	Out	—
	88	.0221	—
	89	—	Out
	95	—	3.09
	96	1.4712	—
	97	—	Out
	99	—	.985

Window	Sensor Number	P_x psia	$\dot{m}_{in}/\dot{m}_{out}$
	None	None	None
	None	None	None

Table 139
Test Pt. 14, Run 22/0, Horizontal Two-Engine Conf.

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Fuselage
53	—	1.53	
56	Out	—	
57	Out	—	
58	Out	—	
62	—	1.19	
63	—	Out	
64	—	.00	
68	.0061	—	
69	.0039	—	
70	Out	—	
71	.0000	—	
74	—	Out	
75	—	.00	
80	.0051	—	
81	.0059	—	
82	.0002	—	
83	.0000	—	
90	.0024	—	
91	.0004	—	
92	.0023	—	
93	.0001	—	

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Tail
78	—	—	
89	—	—	
97	—	—	
100	—	—	

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Wing
None	None	None	None

LMSC-HREC D225839

Table 140
Test Pt. 15, Run 27/0, Equivalent Engine Conf.

Sensor Number	P _x psia	ζ Btu/ft ² sec	
36	.0018	—	
50	.0018	—	
57	.0026	—	
70	.0002	—	
82	.00030	—	
83	.0004	—	
93	Out-	—	

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	
60		.0343	—
61		—	23.41
66		—	43.91
67		.1030	—
72		—	Out
73		—	Out
77		.2070	—
78		—	Out
79		.0484	—
85		—	8.57
87		.4633	—
88		.0235	—
89		—	Out
95		—	3.79
96		.4054	—
97		—	Out
98		Out	—
99		—	1.21

Wing		
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
None	None	None

Table 141
Test Pt. 15, Run 27/1, Equivalent Engine Conf.

Fuselage		Tail		Wing	
Sensor Number	P _x psia	q̄ Btu/ft ² sec	Sensor Number	P _x psia	q̄ Btu/ft ² sec
36	Out	—	60	.0590	—
50	Out	—	61	—	53.31
57	.0024	—	66	—	144.73
70	.0030	—	67	.1220	—
82	.0024	—	72	—	Out
83	Out	—	73	—	Out
93	.0010	—	77	.4120	—
			78	—	362.84
			79	.0685	—
			85	—	13.01
			87	.3293	—
			88	.0316	—
			89	—	Out
			95	—	5.18
			96	.3132	—
			97	—	Out
			98	.0003	—
			99	—	1.43

LMSC-HREC D225839

Table 142
Test Pt. 15, Run 28/0, Equivalent Engine Conf.

Sensor Number	P_x psia	$\dot{\epsilon}_1$ Btu/ft ² sec
33	.0061	—
34	.0075	—
35	.0063	—
47	.0072	—
48	.0050	—
49	.0007	—
53	—	.231
55	.0047	—
56	.0018	—
62	—	.662
63	—	.260
64	—	.732
68	.0087	—
69	.0063	—
74	—	1.32
75	—	.889
80	.0087	—
81	.0089	—
90	.0058	—
91	Out	—
92	.0051	—

Sensor Number	P_x psia	$\dot{\epsilon}_1$ Btu/ft ² sec
73	—	Out
89	—	Out
97	—	Out
100	—	1.578

Sensor Number	P_x psia	$\dot{\epsilon}_1$ Btu/ft ² sec
None	None	None

Table 14
Test Pt. 15, Run 28/1, Equivalent Engine Conf.

Sensor Number	P_x psia	\dot{q} Btu/ft ² sec
33	.0026	--
34	.0014	--
35	.0016	--
47	.0077	--
48	.0048	--
49	.0036	--
53	--	2.01
55	.008%	--
56	.0045	--
62	--	2.18
63	--	Out
64	--	.166
68	.0060	--
69	.0040	--
74	--	1.25
75	--	.750
80	Out	--
81	.0052	--
90	.0039	--
91	Out	--
92	.0026	--

Sensor Number	P_x psia	\dot{q} Btu/ft ² sec
73	--	Out
89	--	Out
97	--	Out
100	--	1.52

Wing		
Sensor Number	P_x psia	\dot{q} Btu/ft ² sec
None	None	None

Table 144
Test Pt. 15, Run 96/0, Equivalent Engine Conf.

Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	
19	.00065	—	
25	Out	—	
26	.00143	—	
27	Out	—	
28	Out	—	
29	Out	—	
33	.00292	—	
34	.00205	—	
35	.00138	—	
36	Out	—	
37	Out	—	
47	Out	—	
48	.00120	—	
49	.00211	—	
50	.00101	—	
51	Out	—	
55	.00817	—	
56	Out	—	
57	Out	—	
58	Out	—	
62	—	Out	
63	—	Out	
64	—	Out	

Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	
60	.02646	—	
61	—	Out	
67	.08755	—	
73	—	Out	
77	.19870	—	
79	.03885	—	
85	—	Out	
87	.54444	—	
88	.02218	—	
95	—	Out	
96	.45881	—	
99	—	Out	
100	—	Out	

Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	
None	None	None	

Table 144 (Continued)
Test Pt. 15, Run 96/0, Equivalent Engine Conf.

Fuselage	Sensor Number	P _x psia	dot q Btu/ft ² sec
	68	.00678	—
	69	Out	—
	70	Out	—
	71	Out	—
	74	—	Out
	75	—	Out
	80	.00367	—
	81	.00438	—
	82	.00645	—
	90	.00357	—
	91	.00468	—
	92	.00138	—

Tail	Sensor Number	P_k psia	\dot{q} $Btu/ft^2 \text{ sec}$

Wing	\dot{q} Btu/ ft^2 sec		
Sensor Number	P_x psia	None	None
None	None		

Table 145
Test Pt. 15, Run 96/1, Equivalent Engine Conf.

Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	Fuselage
19	.00114	—	
25	Out	—	
26	.00250	—	
27	.00271	—	
28	Out	—	
29	.00022	—	
30	—	.48	
33	.00384	—	
34	.00307	—	
35	.00217	—	
36	.00204	—	
37	Out	—	
39	—	.84	
47	.00424	—	
48	.00289	—	
49	.00264	—	
50	Out	—	
51	.00033	—	
5	.00723	—	
56	Out	—	
57	.00206	—	
58	Out	—	
62	—	2.46	
63	—	.70	

Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	Tail
60	.03903	—	
61	—	21.6	
67	.08755	—	
73	—	2.42	
77	.18982	—	
79	.04277	—	
85	—	7.97	
87	.50076	—	
88	.02401	—	
95	—	3.47	
96	.35613	—	
99	—	1.09	
100	—	1.34	

Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	Wing
None	None	None	None

Table I45 (Continued)
Test Pt. 15, Run 96/1. Equivalent Engine Conf.

Fuselage			
Sensor Number	P _x Psi	dot q Btu/ft ² sec	
64	—	.13	
68	.00770	—	
69	.00457	—	
70	Out	—	
71	Out	—	
74	—	.32	
75	—	Out	
80	.00262	—	
81	Out	—	
82	Out	—	
90	.00307	—	
91	.00498	—	
92	.00092	—	

	Tail		
Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	

Wing			
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	
None	None	None	

Table 146
Test Pt. 15*, Run 55/1, Equivalent Engine Conf.

Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	Fuselage
39	—	1.52	
40	—	.56	
53	—	2.58	
62	—	3.05	
63	—	1.02	
64	—	.43	
74	—	2.35	
75	—	1.35	

Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	Tail
51	—	—	
66	—	—	
72	—	—	
73	—	—	
85	—	—	
69	—	—	
95	—	—	
87	—	—	
99	—	—	
100	—	—	

Wing	
Sensor Number	P_x psia
None	None

* Y coordinate location off by + 0.445 inch

Table 147
Test Pt. 15*, Run 56/1, Equivalent Engine Conf.

Fuselage				Tail				Wing			
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
40	—	.25	61	—	23.90	No.e	None	None	None	None	None
62	—	2.29	66	—	42.54						
63	—	.75	85	—	4.43						
74	—	1.39	100	—	1.48						

* Y coordinate location off by + 0.445 inch

LMSC-HREC D225839

Table 148
Test Pt. 15*, Run 80/1, Horizontal Two-Engine Conf.

Fuselage			Tail			Wing		
Sensor Number	P _X psia	q̄ Btu/ft ² sec	Sensor Number	P _X psia	q̄ Btu/ft ² sec	Sensor Number	P _X psia	q̄ Btu/ft ² sec
30	—	.21	61	—	19.86	None	None	None
39	—	1.89	66	—	36.80			
40	—	.34	85	—	3.58			
53	—	2.39	95	—	5.80			
62	—	2.84						
74	—	1.50						
75	—	1.04						

* Y coordinate location off by + 0.445 inch

Table 149
Test Pt. 15*, Run 81/1, Horizontal Two-Engine Conf.

Fuselage		
Sensor Number	P _x psia	q̇ Btu/ft ² sec
30	—	.23
39	—	.26
40	—	.46
62	—	3.50
63	—	.78
74	—	2.15

Tail		
Sensor Number	P _x psia	q̇ Btu/ft ² sec
61	—	25.1
66	—	45.7
85	—	4.46
95	—	6.79
99	—	1.29
100	—	1.46

Wing		
Sensor Number	P _x psia	q̇ Btu/ft ² sec
None	None	None

* Y coordinate location off by + 0.445 inch

Table 150
Test Pt. 15, Run 25/0, Horizontal Two-Engine Conf.

LM3C-HREC D225839

Fuselage		Wing		
Sensor Number	P _x psia	q̄ Btu/ft ² sec	Sensor Number	P _x psia
36	Out	—	60	.0577
50	.0022	—	61	—
57	Out	—	66	—
70	.0002	—	67	.1100
82	.0034	—	72	—
83	.0002	—	73	—
93	.0006	—	77	.1916
			78	—
			79	.0659
			85	—
			87	.6354
			88	Out
			89	—
			95	—
			96	.5602
			97	—
			98	.0017
			99	—

Tail		Wing		
Sensor Number	P _x psia	q̄ Btu/ft ² sec	Sensor Number	P _x psia
60	.0577	—	None	None
61	—	—	None	None
66	—	—	None	None
67	—	—	None	None
72	—	—	None	None
73	—	—	None	None
77	—	—	None	None
78	—	—	None	None
79	—	—	None	None
85	—	—	None	None
87	—	—	None	None
88	Out	—	None	None
89	—	—	None	None
95	—	—	None	None
96	—	—	None	None
97	—	—	None	None
98	—	—	None	None
99	—	—	None	None

Table 151
Test Pt. 15, Run 26/0, Horizontal Two-Engine Conf.

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Fuselage
33	Out	—	
34	Out	—	
35	.0034	—	
47	Out	—	
48	.0132	—	
49	Out	—	
53	—	2.616	
55	.0136	—	
56	.0026	—	
62	—	3.19	
63	—	.978	
64	—	.144	
68	.0149	—	
69	Out	—	
74	—	2.056	
75	—	Out	
80	.0103	—	
81	.0106	—	
90	.0061	—	
91	.0125	—	
92	Out	—	

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Tail
73	—	—	Wing
89	—	—	
97	—	—	
100	—	—	

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Wing
None	None	None	None

Table 152
Test Pt. 17, Run 79/0, Equivalent Engine Conf.

Sensor Number	Fuselage	P_x psia	\dot{q} Btu/ft ² sec
39	—	.23	
40	—	.16	
53	—	Out	
62	—	.09	
63	—	Out	
64	—	.20	
74	—	Out	
75	—	Out	
90	.00042	—	
91	.00049	—	
92	Out	—	

Sensor Number	Tail	P_x psia	\dot{q} Btu/ft ² sec
61	—	—	.65
66	—	—	.83
72	—	—	1.23
73	—	—	3.95
77	.00948	—	
78	—	—	15.87
79	.00159	—	
85	—	Out	
87	Out	—	
88	.00397	—	
89	—	—	33.29
95	—	—	.67
96	.08338	—	
97	—	—	112.95
98	.00027	—	
99	—	—	.35
100	—	—	.35

LMSC-HREC D225839

Table 153
Test Pt. 17, Run 79/1, Equivalent Engine Conf.

Fuselage				Tail				Wing			
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec		Sensor Number	P _x psia	\dot{q} Btu/ft ² sec		Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	
39	—	.20		61	—	.63		None	None	None	
40	—	.14		66	—	1.03					
53	—	.25		72	—	1.38					
62	—	.17		73	—	4.14					
63	—	.18		77	Out	—					
64	—	.13		78	—	12.31					
74	—	.13		79	Out	—					
75	—	.06		85	—	1.36					
90	Out	—		87	Out	—					
91	Out	—		88	Out	—					
92	Out	—		89	—	32.61					
				95	—	.66					
				96	Out	—					
				97	—	141.62					
				98	Out	—					
				99	—	.28					
				100	—	.33					

Table 154
Test Pt. 17, Run 23/1, Horizontal Two-Engine Conf.

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Fuselage		
33	.0009	—			
34	Out	—			
35	.0005	—			
36	.0001	—			
47	.0009	—			
48	Out	—			
49	.0005	—			

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	Tail		
			Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
60	.0035	—			
61	—	1.660.			
66	—	2.510			
67	Out	—			
72	—	4.520			
73	—	7.580			
77	.0112	—			
78	—	12.05			
79	.0040	—			
85	—	1.450			
87	.0510	—			
88	.0019	—			
89	—	32.95			
95	—	Out			
96	.1429	—			
97	—	77.56			
98	.0009	—			
99	—	.18			

LMSC-HREC D225839

Table 155
Test Pt. 17, Run 24/0, Horizontal Two-Engine Conf.

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
50	.0002	—
51	.0002	—
55	.0019	—
56	.0004	—
57	.0002	—
58	.0000	—
68	.0019	—
69	.0013	—
70	.0004	—
71	.0001	—
80	.0011	—
81	.0017	—
82	.0008	—
83	.0001	—
90	.0017	—
91	.0011	—
92	.0004	—
93	.0001	—
53	—	Out
62	—	.54
63	—	.18
64	—	.07
74	—	.30
75	—	.15

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
100	—	.24

Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
None	None	None

Table 156
Test Pt. 17, Run 78/0, Horizontal Two-Engine Conf.

Fuselage		Tail		Wing	
Sensor Number	P _x psia	q̇	Sensor Number	P _x psia	q̇
53	—	.59	61	—	2.81
62	—	.69	66	—	4.42
63	—	.17	72	—	5.86
64	—	Out	73	—	9.24
74	—	Out	77	.02501	—
75	—	Out	78	—	14.86
90	Out	—	79	.00998	—
91	Out	—	85	—	1.69
92	Out	—	87	.05146	—
			88	.00118	—
			89	—	42.93
			95	—	.94
			96	.12304	—
			97	—	91.22
			98	Out	—
			99	—	.33
			100	—	.46

Table 157
Test Pt. 17, Run 78/1, Horizontal Two-Engine Conf.

Fuselage		Tail		Wing	
Sensor Number	P _x psia	q̇	P _x psia	q̇	P _x psia
53	—	Out	61	—	2.91
62	—	.72	66	—	3.64
63	—	Out	72	—	5.33
64	—	.04	73	—	8.53
74	—	.04	77	.01448	—
75	—	Out	78	—	13.79
90	.00080	—	79	.00257	—
91	.00104	—	85	—	Out
92	.00029	—	87	.05866	—
			88	.09779	—
			89	—	39.75
			95	—	.24
			96	.16412	—
			97	—	84.90
			98	.00030	—
			99	—	.30
			100	—	.30

Table 158
Test Pt. 17, Run 63/0, Vertical Two-Engine Conf.

LMSC-HREC D225839

Wing			
Sensor Number	P _x psia	q̇ Btu/ft ² sec	
None	None	None	None
61	—	.31	
66	—	1.03	
72	—	2.21	
73	—	5.31	
77	.00575	—	
78	—	8.96	
79	.00094	—	
85	—	.97	
87	Out	—	
88	.00040	—	
89	—	33.44	
95	—	.53	
96	.13300	—	
97	—	Out	
99	—	.16	
100	—	.23	

Tail			
Sensor Number	P _x psia	q̇ Btu/ft ² sec	
61	—	.31	
66	—	1.03	
72	—	2.21	
73	—	5.31	
77	.00575	—	
78	—	8.96	
79	.00094	—	
85	—	.97	
87	Out	—	
88	.00040	—	
89	—	33.44	
95	—	.53	
96	.13300	—	
97	—	Out	
99	—	.16	
100	—	.23	

Fuselage			
Sensor Number	P _x psia	q̇ Btu/ft ² sec	
53	—	.17	
62	—	.18	
63	—	.10	
64	—	.08	
74	—	.17	
75	—	.04	
90	.00022	—	

Table 159
Test Pt. 17, Run 64/0, Vertical Two-Engine Conf.

Sensor Number	Fuselage	P_x psia	\dot{q} Btu/ft ² sec
53	—	Out	.00024
62	—	.20	Out
63	—	.10	Out
64	—	.10	Out
74	—	—	Out
75	—	—	Out
90	—	—	—

Sensor Number	Tail	P_x psia	\dot{q} Btu/ft ² sec
61	—	—	.62
66	—	—	1.63
72	—	—	2.57
73	—	—	5.54
77	.00696	—	—
78	—	—	10.05
79	.00117	—	—
85	—	—	1.10
87	Out	—	—
88	.00054	—	—
89	—	—	35.16
95	—	—	.60
96	.14808	—	—
97	—	—	Out
99	—	—	.20
100	—	—	.00

Sensor Number	Wing	P_x psia	\dot{q} Btu/ft ² sec
None	None	None	None

Table 160
Test Pt. 29, Run 95/0, Equivalent Engine Conf.

Fuselage		Tail		
Sensor Number	P _x psia	q̇ Btu/ft ² sec	Sensor Number	P _x psia
None	None	None	61	—

Fuselage		Tail		
Sensor Number	P _x psia	q̇ Btu/ft ² sec	Sensor Number	P _x psia
None	None	None	66	—
			72	—
			73	—
			7.	.01551
			78	—
			79	.00402
			85	—
			87	.07677
			88	.00184
			95	—
			96	.21983
			98	.00100
			99	—
			100	.54

LMSC-HREC D225839

Table 161
Test Pt. 29, Run 95/1, Equivalent Engine Conf.

Fuselage				Tail				Wing			
Sensor Number	P _x psia	dot q	Btu/ft ² sec	Sensor Number	P _x psia	dot q	Btu/ft ² sec	Sensor Number	P _x psia	dot q	Btu/ft ² sec
None	None	None	None	61	—	.87	—	None	None	None	None
				66	—	2.51	—				
				72	—	46.90	—				
				73	—	9.61	—				
				77	.01551	—	—				
				78	—	17.08	—				
				79	.00402	—	—				
				85	—	1.76	—				
				87	.07677	—	—				
				88	.00184	—	—				
				95	—	.84	—				
				96	.21983	—	—				
				98	.00100	—	—				
				99	—	Out	—				
				100	—	.41	—				

Table 162
Test Pt. 29, Run 34/0, Horizontal Two-Engine Conf.

Fuselage		
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
33	.0008	—
34	.001	—
35	.0006	—
36	Out	—
47	.0019	—
48	.0011	—
49	.0000	—

Tail		
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
60	.0008	—
61	—	Out
66	—	4.07
67	.0000	—
72	—	10.02
73	—	Out
77	.0348	—
78	—	23.94
79	.0056	—
85	—	1.95
87	.0954	—
88	Out	—
89	—	Out
95	—	1.08
96	.3679	—
97	—	Out
98	.0021	—
99	—	.59

Wing		
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec
None	None	None

LMSC - HREC D225839

Table 16³
Test Pt. 29, Run 35/1, Horizontal Two-Engine Conf.

Sensor Number	P _x psia	q̄ Btu/ft ² sec
50	.0002	—
51	.0001	—
55	.0019	—
56	.0004	—
57	.0004	—
58	.0001	Out
68	.0020	Out
69	.0007	Out
70	.0007	Out
71	.0000	Out
80	.0000	Out
81	.0000	Out
82	.0000	Out
83	.0001	Out
90	.0001	Out
91	.0016	Out
92	.0016	—
93	.0001	—
53	—	.56
62	—	.69
63	—	.15
64	—	.07
74	—	.40
75	—	.39

Sensor Number	P _x psia	q̄ Btu/ft ² sec
100	—	0.50

Sensor Number	P _x psia	q̄ Btu/ft ² sec
None	None	None

LMSC-HREC D225839

Table 164
Test Pt. 29, Run 94/0, Horizontal Two-Engine Conf.

Fuselage		Tail			Wing			
Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	Sensor Number	P_x psia	\dot{q} Btu/ft ² sec
None	None	None	61	—	4.10	None	None	None
			66	—	6.81			
			72	—	8.90			
			73	—	14.32			
			77	.02506	—			
			78	—	24.93			
			79	.00690	—			
			85	—	2.28			
			87	.10380	—			
			88	.00314	—			
			95	—	1.17			
			96	.30190	—			
			98	.00189	—			
			99	—	.50			
			100	—	.57			

Table 165
Test Pt. 29, Run 94/1, Horizontal Two-Stage Conf.

Fuselage				Tail				Wing			
Sensor Number	P _x psia	q̄ Btu/ft ² sec	None	Sensor Number	P _x psia	q̄ Btu/ft ² sec	None	Sensor Number	P _x psia	q̄ Btu/ft ² sec	None
None	None	None	None	61	—	3.83	None	None	None	None	None
				66	—	7.61					
				72	—	8.21					
				73	—	12.25					
				77	.02368	—					
				78	—	19.81					
				79	.00628	—					
				85	—	1.69					
				87	.09757	—					
				88	.00297	—					
				95	—	.86					
				96	.25545	—					
				98	.00172	—					
				99	—	.36					
				100	—	.51					

LMSC-HREC D225839

Table 166
Test Pt. 29, Run 93/0, Vertical Two-Engine Conf.

Fuselage				Tail				Wing			
Sensor Number	R _x psia	q̄ Btu/ft ² sec		Sensor Number	R _x psia	q̄ Btu/ft ² sec		Sensor Number	P _x psia	q̄ Btu/ft ² sec	
None	None	None		61	—	.99		None	None	None	
				66	—	2.22					
				72	—	5.65					
				73	—	10.90					
				77	.01978	—					
				78	—	21.75					
				79	.00378	—					
				85	—	1.83					
				87	.08814	—					
				88	.00152	—					
				95	—	.94					
				96	.43793	—					
				98	.00068	—					
				99	—	.35					
				100	—	.45					

Table 167
Test Pt. 29, Run 93/1, Vertical Two-Engine Conf.

Sensor Number	Fuselage	P_x psia	\dot{q} Btu/ft ² sec
None	None	None	None

Sensor Number	Tail	P_x psia	\dot{q} Btu/ft ² sec
61	—	—	1.21
66	—	—	2.64
72	—	—	5.28
73	—	—	10.54
77	.01823	—	—
78	—	—	16.80
79	.00369	—	—
85	—	—	1.62
87	.07616	—	—
88	.00131	—	—
95	—	—	.97
96	.43177	—	—
98	.00062	—	—
99	—	—	.36
100	—	—	.54

Sensor Number	Wing	P_x psia	\dot{q} Btu/ft ² sec
None	None	None	None

LMSC-HREC D225839

Table 168
Test Pt. 30, Run 84/0, Equivalent Engine Conf

Fuselage		Wing		
Sensor Number	P_x psia	\dot{q}	P_x psia	\dot{q}
	Btu/ft ² sec	Btu/ft ² sec		Btu/ft ² sec
None	None	None	None	None

Tail		Wing		
Sensor Number	P_x psia	\dot{q}	P_x psia	\dot{q}
	Btu/ft ² sec	Btu/ft ² sec		Btu/ft ² sec
61	—	19.36	None	None
66	—	4.62	None	None
72	—	8.52	None	None
73	—	6.88	None	None
77	.01574	—	None	None
78	—	18.96	None	None
79	.00260	—	None	None
85	—	1.38	None	None
87	.04700	—	None	None
88	.00098	—	None	None
89	—	Out	None	None
95	—	.90	None	None
96	.14773	—	Out	None
99	—	.43	None	None
100	—	—	None	None

Table 169
Test Pt. 30, Run 84/1, Equivalent Engine Conf.

Fuselage		Tail			Wing			
Sensor Number	P _x psia	q̄ Btu/ft ² sec	Sensor Number	P _x psia	q̄ Btu/ft ² sec	Sensor Number	P _x psia	q̄ Btu/ft ² sec
None	None	None	61	—	2.05	None	None	None
			66	—	4.38			
			72	—	10.34			
			73	—	Out			
			77	.01818	—			
			78	—	18.97			
			79	.00322	—			
			85	—	1.12			
			87	.04945	—			
			88	.00130	—			
			89	—	Out			
			95	—	1.01			
			96	.1506	—			
			99	—	Out			
			100	—	.41			

Table 170
Test Pt. 30, Run 37/0, Equivalent Engine Conf.

Fuselage	P_x psia	\dot{q} Btu/ft ² sec
Sensor Number		
50	.0002	—
51	.0008	—
55	.0005	—
56	.0002	—
57	.0003	—
58	.0003	—
68	Out	—
69	.0005	—
70	.0004	—
71	Out	—
80	Out	—
81	Out	—
82	Out	—
83	.0002	—
90	.0005	—
91	Out	—
92	Ort	—
93	.0001	—
53	—	.308
62	—	.247
63	—	.292
64	—	.314
74	—	.211
75	—	.263

Tail	P_x psia	\dot{q} Btu/ft ² sec
Sensor Number		
100	—	.428

Wing	P_x psia	\dot{q} Btu/ft ² sec
Sensor Number		
None	None	None

Table 171
Test Pt. 30, Run 36/0, Horizontal Two-Engine Conf.

Sensor Number	P_x psia	\dot{q} Btu/ft ² sec
33	.0026	—
34	.0013	—
35	Out	—
36	.0000	—
47	Out	—
48	Out	—
49	Out	—

Sensor Number	P_x psia	\dot{q} Btu/ft ² sec
60	Out	—
61	—	Out
66	—	22.34
67	Out	—
72	—	16.90
73	—	2.38
77	.0306	—
78	—	33.31
79	.0038	—
85	—	1.86
87	.0920	—
88	.0021	—
89	—	Out
95	—	.103
96	.1366	—
97	—	Out
98	.0000	—
99	—	.265

Table 172
Test Pt. 30, Run 97/0, Horizontal Two-Engine Conf.

Sensor Number	Fuselage	P_x psia	\dot{q} Btu/ft ² sec
None	None	None	None

Sensor Number	Tail	R_x psia	\dot{q} Btu/ft ² sec
61	—	—	4.95
66	—	—	8.33
72	—	—	12.51
73	—	—	Out
77	.03774	—	—
78	—	—	28.79
79	.00756	—	—
85	—	—	2.53
87	.09285	—	—
88	.00329	—	—
89	—	—	68.06
95	—	—	1.16
96	.27502	—	—
99	—	—	.48
100	—	—	.64

Sensor Number	Wing	P_x psia	\dot{q} Btu/ft ² sec
None	None	None	None

Table 173
Test Pt. 30, Run 97/1 Horizontal Two-Engine Conf.

Fuselage				Tail				Wing			
Sensor Number	P _X psia	q̇ Btu/ft ² sec	None	Sensor Number	P _X psia	q̇ Btu/ft ² sec	None	Sensor Number	P _X psia	q̇ Btu/ft ² sec	None
None	None	None	None	61	—	3.69	None	None	None	None	None
				66	—	6.11					
				72	—	8.49					
				73	—	8.10					
				77	.02653	—					
				78	—	19.71					
				79	.00479	—					
				85	—	1.81					
				87	.06221	—					
				88	.00194	—					
				89	—	45.30					
				95	—	.83					
				96	.17131	—					
				99	—	.30					
				,00	—	.47					

Table 174
Test Pt. 30, Run 83/0, Vertical Engine Conf.

Fuselage			
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	
None	None	None	

Tail			
Sensor Number	P _x psia	\dot{q} Btu/ft ² sec	
6i	—	1.32	
66	—	4.31	
72	—	7.96	
73	—	7.15	
77	.01456	—	
78	—	18.57	
79	.00230	—	
85	—	1.78	
87	.04639	—	
88	.00086	—	
89	—	56.08	
95	—	.75	
96	.18423	—	
99	—	.26	
100	—	.37	

LMSC-HREC D245839

Table 175
Test Pt. 30, Run 83/1, Vertical Engine Conf.

Fuselage		
Sensor Number	P _x psia	q̇ Btu/ft ² sec
None	None	None

Tail		
Sensor Number	P _x psia	q̇ Btu/ft ² sec
61	—	1.45
66	—	3.82
72	—	7.20
73	—	7.62
77	.01258	—
78	—	17.91
79	.00172	—
85	—	1.45
87	.04731	—
88	.00070	—
89	—	Out
95	—	.05
96	.19754	—
99	—	.22
100	—	.34

Table 176
Test Pt. 31, Run 39/0, Equivalent Engine Conf.

Fuselage		Tail		Wing	
Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	Sensor Number	P_x psia	\dot{q} Btu/ft ² sec
53	—	.373	78	—	Out
56	.0004	—	89	—	Out
57	.0004	—	97	—	Out
58	.0001	—	100	—	1.44
62	—	.302			
63	—	Out			
64	—	.288			
68	Out	—			
69	Out	—			
70	Out	—			
71	.0000	—			
74	—	1.12			
75	—	.333			
80	.0015	—			
81	Out	—			
82	.0012	—			
83	.0001	—			
90	Out	—			
91	Out	—			
92	.0017	—			
93	.0001	—			

Table 177
Test Pt. 31, Run 86/0, Equivalent Engine Conf.

Fuselage		Tail			Wing		
Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	P_x psia	\dot{q} Btu/ft ² sec	Sensor Number	P_x psia	\dot{q} Btu/ft ² sec
None	None	None	61	—	9.17	None	None
			66	—	21.91		
			67	.03060	—		
			72	—	23.36		
			73	—	Out		
			77	.16903	—		
			78	—	Out		
			79	.03157	—		
			85	—	Out		
			87	.52619	—		
			88	.01795	—		
			95	—	3.29		
			96	.84323	—		
			98	.00800	—		
			99	—	Out		
			100	—	1.33		

Table 178
Test Pt. 31, Run 86/1, Equivalent Engine Conf.

Fuselage		Tail			Wing			
Sensor Number	P _x psia	q̄ Btu/ft ² sec	Sensor Number	P _x psia	q̄ Btu/ft ² sec	Sensor Number	P _x psia	q̄ Btu/ft ² sec
None	None	None	61	—	8.45	None	None	None
			66	—	20.35			
			67	.03781	—			
			72	—	19.97			
			73	—	Out			
			77	.19302	—			
			78	—	Out			
			79	.04086	—			
			85	—	1.85			
			87	.72373	—			
			88	.02567	—			
			95	—	.74			
			96	1.05454	—			
			98	.00869	—			
			99	—	.21			
			100	—	.32			

Table 179
Test Pt. 31, Run 38/0, Horizontal Two-Engine Conf.

Fuselage		Tail		Wing	
Sensor Number	P_x psia	\dot{q} Btu/ft ² sec	Sensor Number	P_x psia	\dot{q} Btu/ft ² sec
68	Out	—	60	Out	—
80	Out	—	61	—	9.16
81	Out	—	66	—	23.59
82	.0022	—	67	.0464	—
90	.0039	—	72	—	30.40
91	.0084	—	73	—	Out
92	.0054	—	77	.1554	—
93	.0002	—	78	—	Out
			79	.0233	—
			85	—	5.50
			87	.6110	—
			88	.0238	—
			89	—	Out
			95	—	1.99
			96	1.233	—
			97	—	Out
			99	—	.773

LMSC-HREC D225839

**Appendix B
FIGURES**

LIST OF FIGURES

Figure		Page
1	General Layout of Test Facility	B-1
2	Hot-Flow Wave Schematic	B-2
3	Schematic of 4.242% Nozzle	B-3
4	Schematic of 3% Nozzle Contour	B-4
5	Schematic of Engine Hardware	B-5
6	Schematic of Typical IBFF Probes	B-6
7	Nozzle/Impact Probe Axis System	B-7
8	Equivalent Engine Plume Survey Arrangement	B-8
9	Dual Horizontal Configuration	B-9
10	Dual Vertical Configuration	B-11
11	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 1 from the Engine Exit Plane (Equivalent Engine)	B-12
12	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 1 from the Engine Exit Plane (Vertical Engine Arrangement)	B-13
13	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 1 from the Engine Exit Plane (Horizontal Engine Arrangement)	B-14
14	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 2 from the Engine Exit Plane (Equivalent Engine)	B-15
15	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 2 from the Engine Exit Plane (Vertical Engine Arrangement)	B-16
16	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 2 from the Engine Exit Plane (Horizontal Engine Arrangement)	B-17
17	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 4 from the Engine Exit Plane (Equivalent Engine)	B-18
18	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 4 from the Engine Exit Plane (Vertical Engine Arrangement)	B-19

LIST OF FIGURES (Continued)

Figure		Page
19	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 4 from the Engine Exit Plane (Horizontal Engine Arrangement)	B-20
20	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 10 from the Engine Exit Plane (Equivalent Engine)	B-21
21	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 10 from the Engine Exit Plane (Vertical Engine Arrangement)	B-22
22	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 10 from the Engine Exit Plane (Horizontal Engine Arrangement)	B-23
23	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 12 from the Engine Exit Plane (Equivalent Engine)	B-24
24	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 12 from the Engine Exit Plane (Vertical Engine Arrangement)	B-25
25	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 12 from the Engine Exit Plane (Horizontal Engine Arrangement)	B-26
26	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 15 from the Engine Exit Plane (Equivalent Engine)	B-27
27	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 15 from the Engine Exit Plane (Vertical Engine Arrangement)	B-28
28	Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 15 from the Engine Exit Plane (Horizontal Engine Arrangement)	B-29
29	Radial Distribution of the Plume Stagnation Heating Rates in the Orbiter Main Engine Exhaust Plume at X/D = 10 from the Engine Exit Plane (Equivalent Engine)	B-30
30	Radial Distribution of the Plume Stagnation Heating Rates in the Orbiter Main Engine Exhaust Plume at X/D = 10 from the Engine Exit Plane (Vertical Engine Arrangement)	B-31
31	Radial Distribution of the Plume Stagnation Heating Rates in the Orbiter Main Engine Exhaust Plume at X/D = 10 from the Engine Exit Plane (Horizontal Engine Arrangement)	B-32
32	Radial Distribution of the Plume Stagnation Heating Rates in the Orbiter Main Engine Exhaust Plume at X/D = 15 from the Engine Exit Plane (Equivalent Engine)	B-33

LIST OF FIGURES (Continued)

Figure		Page
33	Radial Distribution of the Plume Stagnation Heating Rates in the Orbiter Main Engine Exhaust Plume at X/D = 15 from the Engine Exit Plane (Vertical Engine Arrangement)	B-34
34	Radial Distribution of the Plume Stagnation Heating Rates in the Orbiter Main Engine Exhaust Plume at X/D = 15 from the Engine Exit Plane (Horizontal Engine Arrangement)	B-35
35	Model Instrumentation Locations - Side View	B-36
36	Model Instrumentation Locations - Top View	B-37
37	Model Instrumentation Locations - Front View	B-38
38	Model and Equivalent Engine Configuration	B-39
39	Model and Dual Horizontal Engine Configuration	B-41
40	Model and Dual Vertical Engine Configuration	B-43
41	Engine/Booster Relative Test Positions	B-44
42	Sketch of Model Geometry and Engine Arrangement	B-45
43	Impingement Pressure Distribution over the Booster Fuselage at Station 87.12 (Test Pos. 2)	B-46
44	Impingement Pressure Distribution over the Booster Fuselage at Station 90.12 (Test Pos. 2)	B-47
45	Impingement Pressure Distribution over the Booster Fuselage at Station 93.12 (Test Pos. 2)	B-48
46	Impingement Pressure Distribution over the Booster Fuselage at Station 96.12 (Test Pos. 2)	B-49
47	Impingement Pressure Distribution over the Booster Fuselage at Station 99.12 (Test Pos. 2)	B-50
48	Impingement Pressure Distribution over the Booster Fuselage at Station 102.12 (Test Pos. 2)	B-51
49	Impingement Pressure Distribution over the Booster Fuselage at Station 105.12 (Test Pos. 2)	B-52
50	Impingement Pressure Distribution over the Booster Fuselage at Station 107.12 (Test Pos. 2)	B-53
51	Impingement Pressure Distribution Along Fuselage Stagnation Line (Test Pos. 2)	B-54
52	Impingement Pressure Distribution Along Dorsal Fin Leading Edge (Test Pos. 2)	B-55
53	Impingement Pressure Distribution Along the Dorsal Fin Chord (Test Pos. 2)	B-56

LIST OF FIGURES (Continued)

Figure		Page
54	Impingement Pressure Distribution over the Booster Fuselage at Station 102.12 (Test Pos. 4)	B-57
55	Impingement Pressure Distribution over the Booster Fuselage at Station 105.12 (Test Pos. 4)	B-58
56	Impingement Pressure Distribution over the Booster Fuselage at Station 107.12 (Test Pos. 4)	B-59
57	Impingement Pressure Distribution Along the Dorsal Fin Leading Edge (Test Pos. 4)	B-60
58	Impingement Pressure Distribution Along the Dorsal Fin Chord (Test Pos. 4)	B-61
59	Impingement Pressure Distribution over the Booster Fuselage at Station 90.12 (Test Positions 5 and 8)	B-62
60	Impingement Pressure Distribution over the Booster Fuselage at Station 93.12 (Test Positions 5 and 8)	B-63
61	Impingement Pressure Distribution over the Booster Fuselage at Station 96.12 (Test Positions 5 and 8)	B-64
62	Impingement Pressure Distribution over the Booster Fuselage at Station 99.12 (Test Positions 5 and 8)	B-65
63	Impingement Pressure Distribution over the Booster Fuselage at Station 102.12 (Test Positions 5 and 8)	B-66
64	Impingement Pressure Distribution over the Booster Fuselage at Station 105.12 (Test Positions 5 and 8)	B-67
65	Impingement Pressure Distribution Along Fuselage Stagnation Line (Test Positions 5 and 8)	B-68
66	Impingement Pressure Distribution Along Dorsal Fin Leading Edge (Test Positions 5 and 8)	B-69
67	Impingement Pressure Distribution Along Dorsal Fin Chord (Test Positions 5 and 8)	B-70
68	Impingement Pressure Distribution over the Booster Fuselage at Station 102.12 (Test Positions 11 and 14)	B-71
69	Impingement Pressure Distribution over the Booster Fuselage at Station 105.12 (Test Positions 11 and 14)	B-72
70	Impingement Pressure Distribution over the Booster Fuselage at Station 107.12 (Test Positions 11 and 14)	B-73
71	Impingement Pressure Distribution Along the Dorsal Fin Leading Edge (Test Positions 11 and 14)	B-74

LIST OF FIGURES (Continued)

Figure		Page
72	Impingement Pressure Distribution along the Dorsal Fin Chord (Test Positions 11 and 14)	B-75
73	Impingement Pressure Distribution over the Booster Fuselage at Station 93.12 (Test Pos. 15)	B-76
74	Impingement Pressure Distribution over the Booster Fuselage at Station 96.12 (Test Pos. 15)	B-77
75	Impingement Pressure Distribution over the Booster Fuselage at Station 99.12 (Test Pos. 15)	B-78
76	Impingement Pressure Distribution over the Booster Fuselage at Station 102.12 (Test Pos. 15)	B-79
77	Impingement Pressure Distribution over the Booster Fuselage at Station 105.12 (Test Pos. 15)	B-80
78	Impingement Pressure Distribution over the Booster Fuselage at Station 107.12 (Test Pos. 15)	B-81
79	Impingement Pressure Distribution along Fuselage Stagnation Line (Test Pos. 15)	B-82
80	Impingement Pressure Distribution along the Dorsal Fin Leading Edge (Test Pos. 15)	B-83
81	Impingement Pressure Distribution along the Dorsal Fin Chord (Test Pos. 15)	B-84
82	Impingement Pressure Distribution over the Booster Fuselage at Station 107.12 (Test Positions 17 and 29)	B-85
83	Impingement Pressure Distribution along the Dorsal Fin Leading Edge (Test Positions 17 and 29)	B-86
84	Impingement Pressure Distribution along the Dorsal Fin Chord (Test Positions 17 and 29)	B-87
85	Impingement Pressure Distribution along the Dorsal Fin Leading Edge (Test Pos. 30)	B-88
86	Impingement Pressure Distribution along the Dorsal Fin Chord (Test Pos. 30)	B-89
87	Impingement Pressure Distribution over the Booster Fuselage at Station 105.12 (Test Pos. 31)	B-90
88	Impingement Pressure Distribution over the Booster Fuselage at Station 107.12 (Test Pos. 31)	B-91
89	Impingement Pressure Distribution along the Dorsal Fin Leading Edge (Test Pos. 31)	B-92
90	Impingement Pressure Distribution along the Dorsal Fin Chord (Test Pos. 31)	B-93

LIST OF FIGURES (Continued)

Figure		Page
91	Heat Transfer Distribution over Fuselage at Station 85.62 (Test Pos. 2)	B-94
92	Heat Transfer Distribution over Fuselage at Station 94.62 (Test Pos. 2)	B-95
93	Heat Transfer Distribution over Fuselage at Station 100.62 (Test Pos. 2)	B-96
94	Heat Transfer Distribution along Fuselage Stagnation Line (Test Pos. 2)	B-97
95	Heat Transfer Distribution along Dorsal Fin Leading Edge (Test Pos. 2)	B-98
96	Heat Transfer Distribution along Dorsal Fin Chord (Test Pos. 2)	B-99
97	Heat Transfer Distribution over Fuselage at Station 94.62 (Test Positions 5 and 8)	B-100
98	Heat Transfer Distribution over Fuselage at Station 100.62 (Test Pos. 5)	B-101
99	Heat Transfer Distribution over Fuselage at Station 103.62 (Test Pos. 5)	B-102
100	Heat Transfer Distribution along Fuselage Stagnation Line (Test Positions 5 and 8)	B-103
101	Heat Transfer Distribution along Dorsal Fin Leading Edge (Test Positions 5 and 8)	B-104
102	Heat Transfer Distribution along Dorsal Fin Chord (Test Positions 5 and 8)	B-105
103	Heat Transfer Distribution over Fuselage at Station 100.62 (Test Pos. 14)	B-106
104	Heat Transfer Distribution over Fuselage at Station 103.62 (Test Pos. 14)	B-107
105	Heat Transfer Distribution over Fuselage at Station 103.62 (Test Pos. 15)	B-108
106	Heat Transfer Distribution along Fuselage Stagnation Line (Test Pos. 15)	B-109
107	Heat Transfer Distribution along Dorsal Fin Leading Edge (Test Pos. 15)	B-110
108	Heat Transfer Distribution along Dorsal Fin Chord (Test Pos. 15)	B-111
109	Heat Transfer Distribution over Fuselage at Station 100.62 (Test Positions 17 and 29)	B-112

LIST OF FIGURES (Concluded)

Figure	Page
110 Heat Transfer Distribution over Fuselage at Station 103.62 (Test Positions 17 and 29)	B-113
111 Heat Transfer Distribution along Dorsal Fin Leading Edge (Test Pos. 17)	B-114
112 Heat Transfer Distribution along Dorsal Fin Chord (Test Pos. 17)	B-115
113 Heat Transfer Distribution along Dorsal Fin Leading Edge (Test Pos. 29)	B-116
114 Heat Transfer Distribution along Dorsal Fin Chord (Test Pos. 29)	B-117
115 Heat Transfer Distribution along Dorsal Fin Leading Edge (Test Pos. 30)	B-118
116 Heat Transfer Distribution along Dorsal Fin Chord (Test Pos. 30)	B-119
117 Heat Transfer Distribution along Dorsal Fin Leading Edge (Test Pos. 31)	B-120
118 Heat Transfer Distribution along Dorsal Fin Chord (Test Pos. 31)	B-121
119 Typical Test Data Curves	B-122

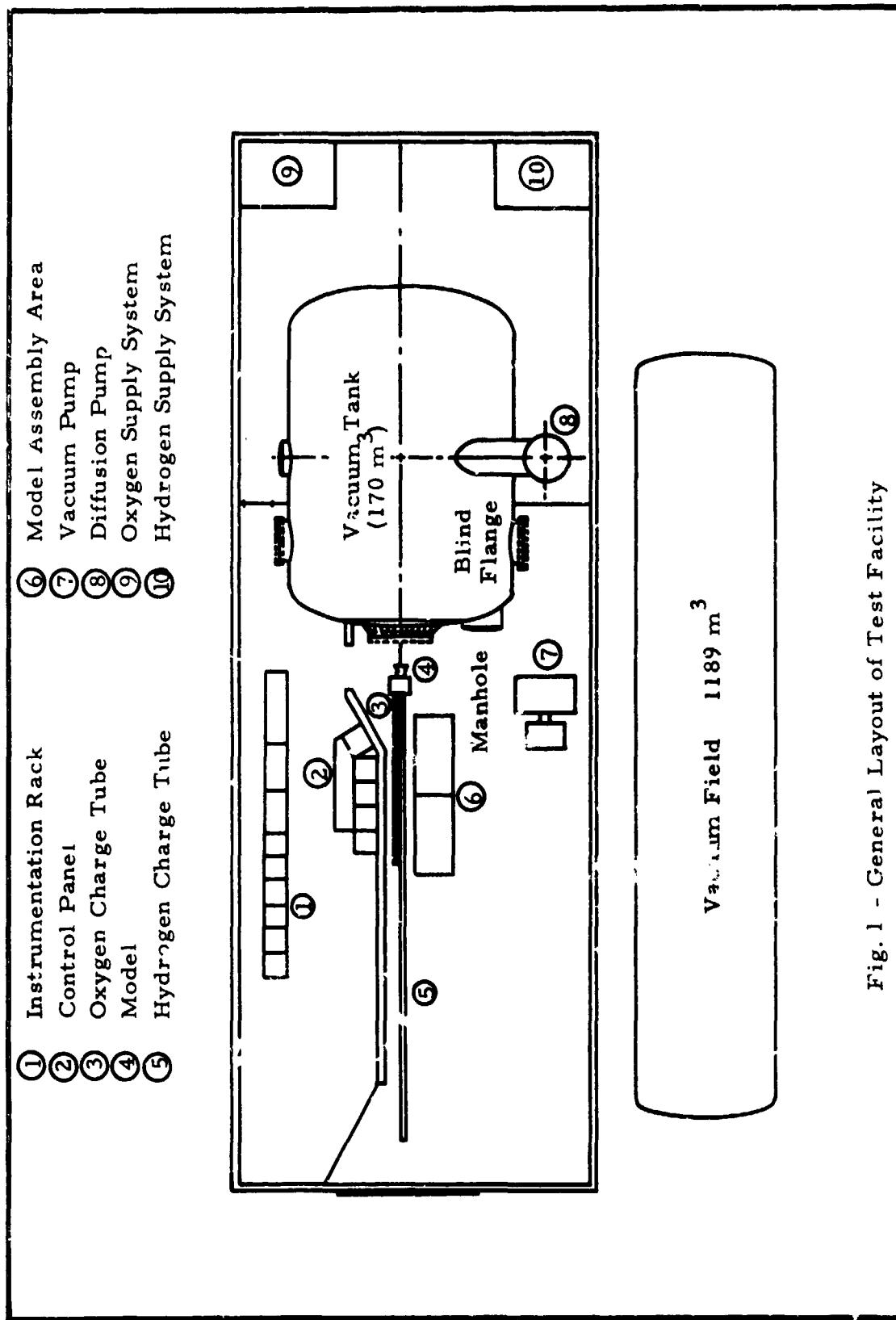


Fig. 1 - General Layout of Test Facility

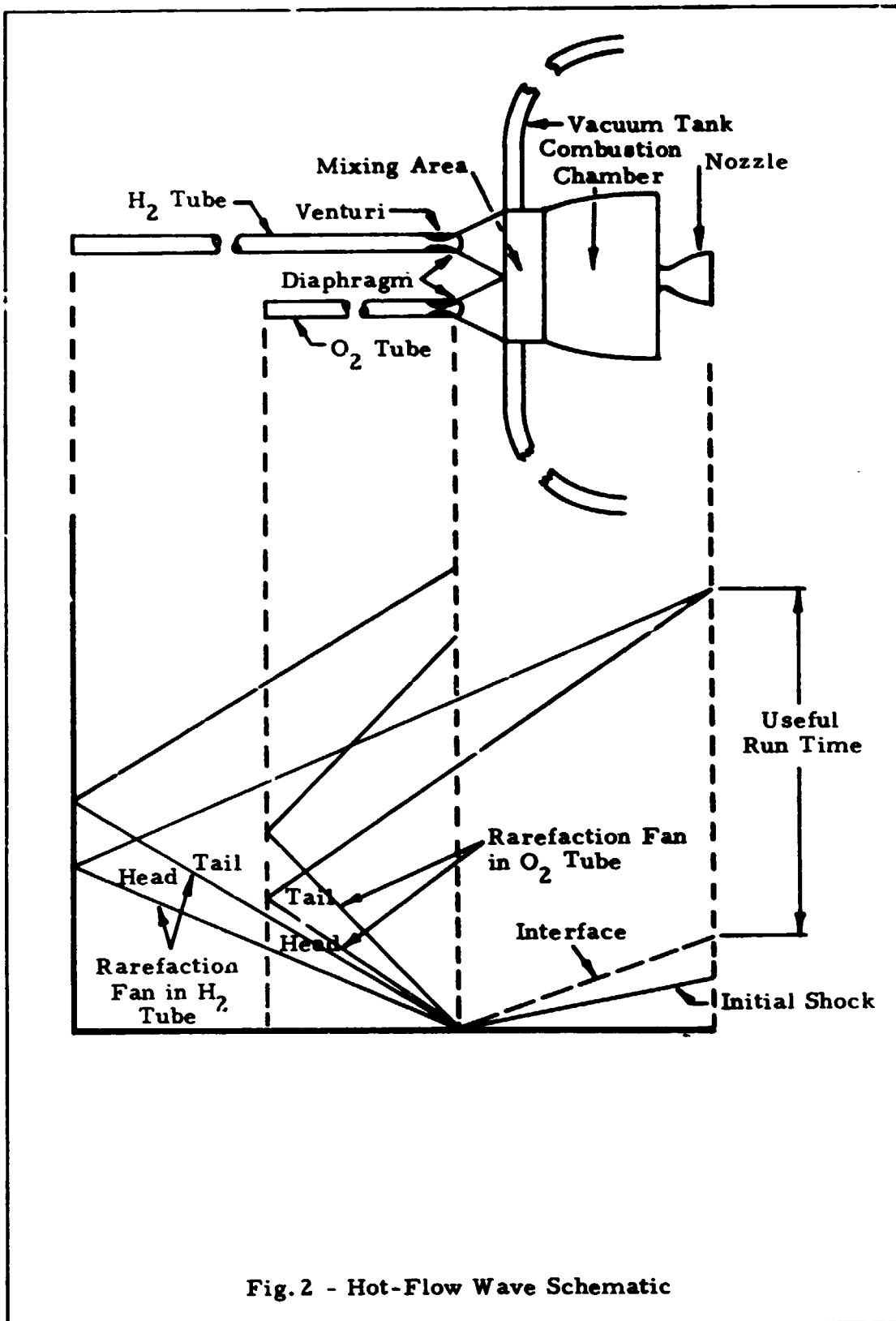


Fig. 2 - Hot-Flow Wave Schematic

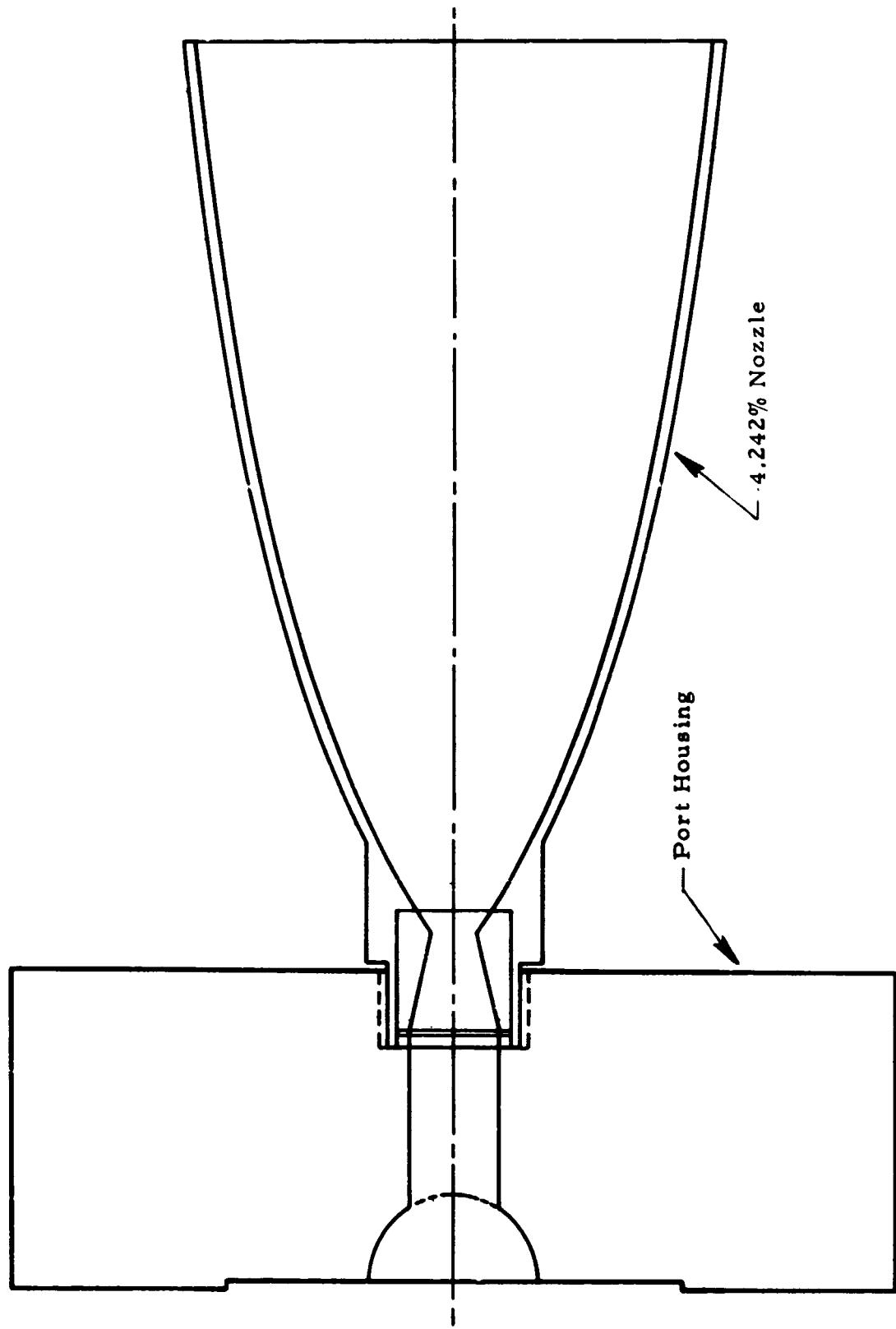


Fig. 3 - Schematic of 4.242% Nozzle

B-3

LMSC-HREC D225839

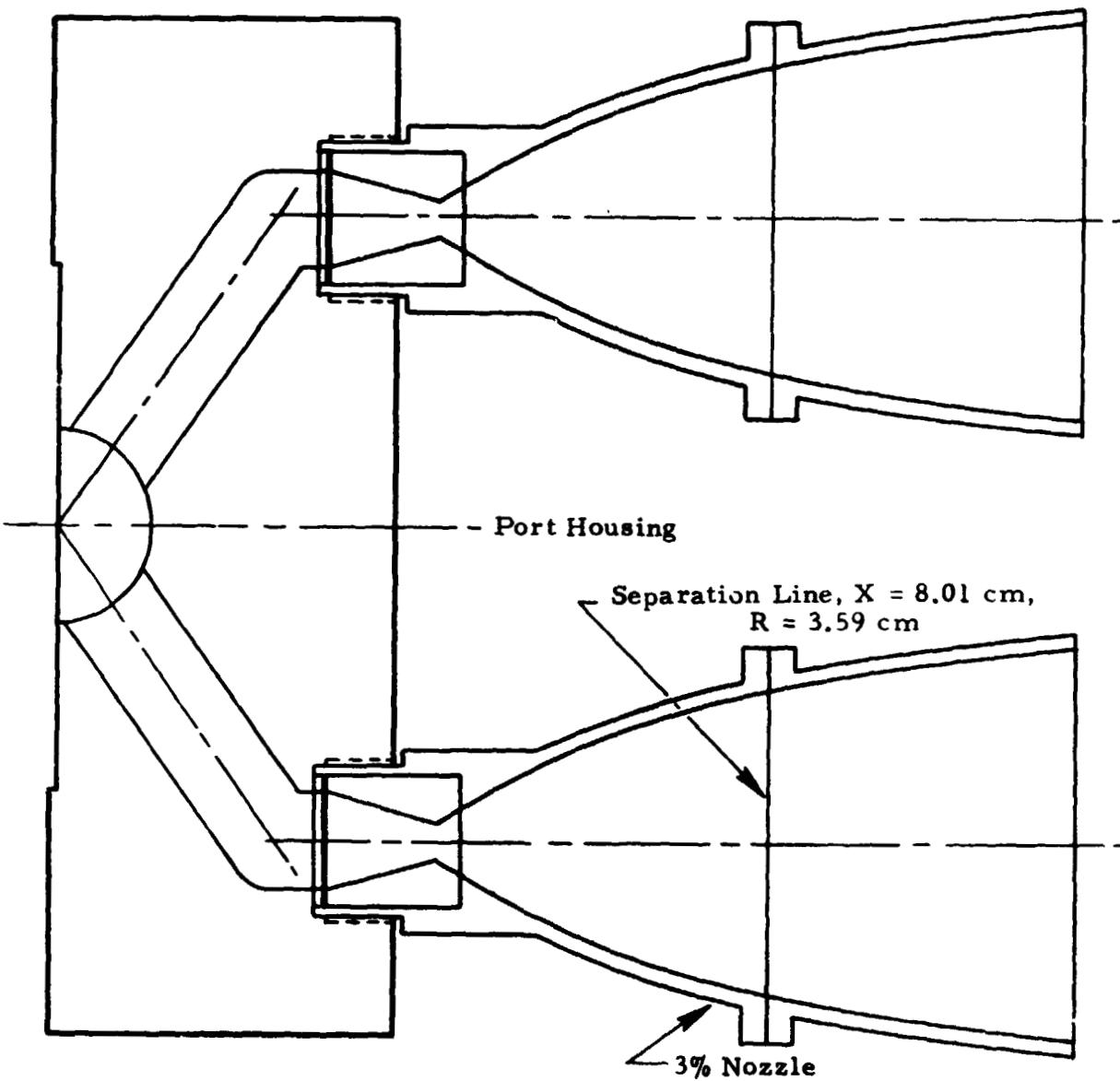


Fig. 4 - Schematic of 3% Nozzle Contour

B4

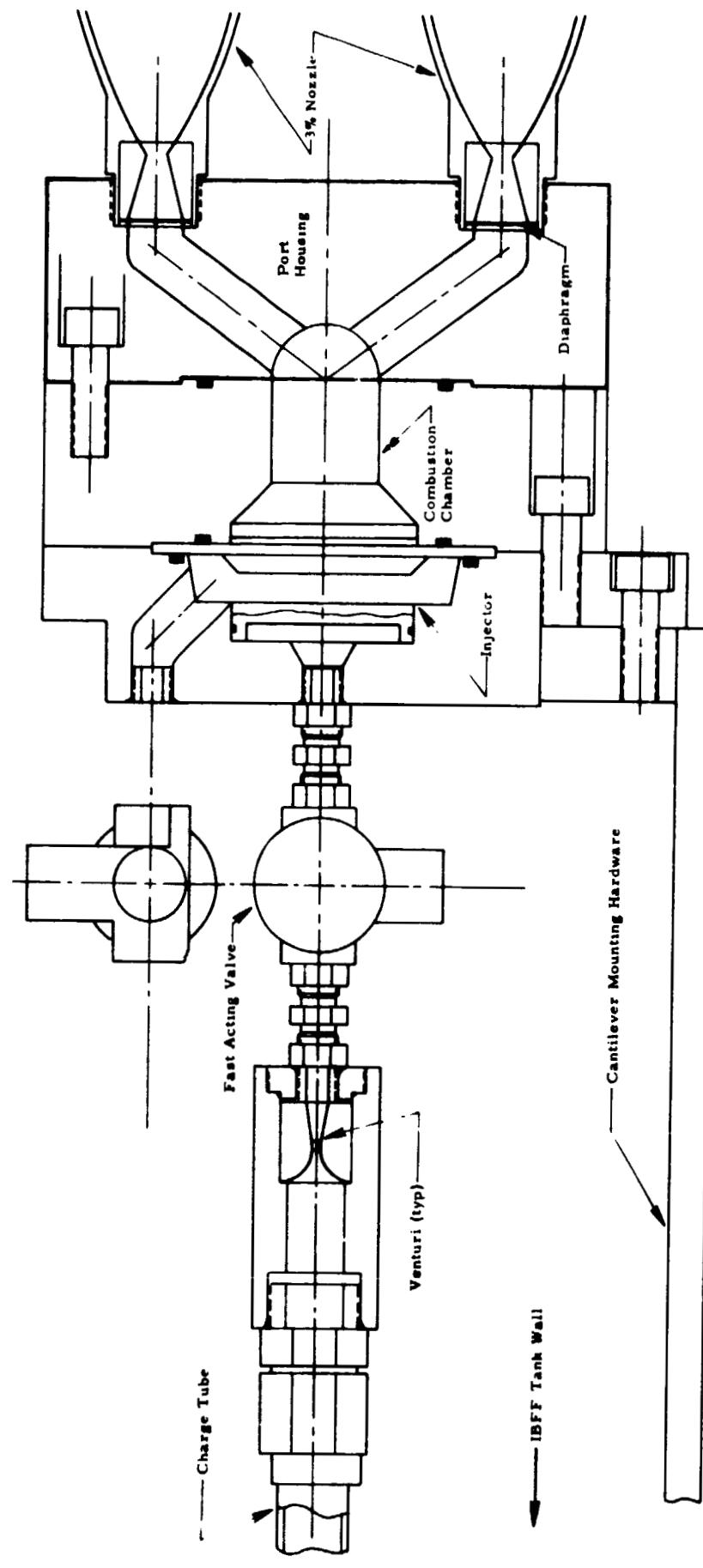
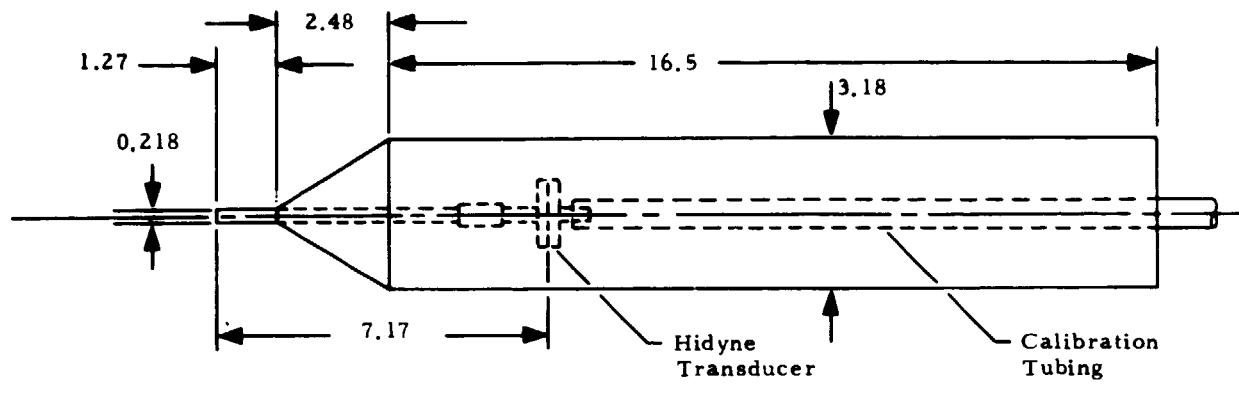
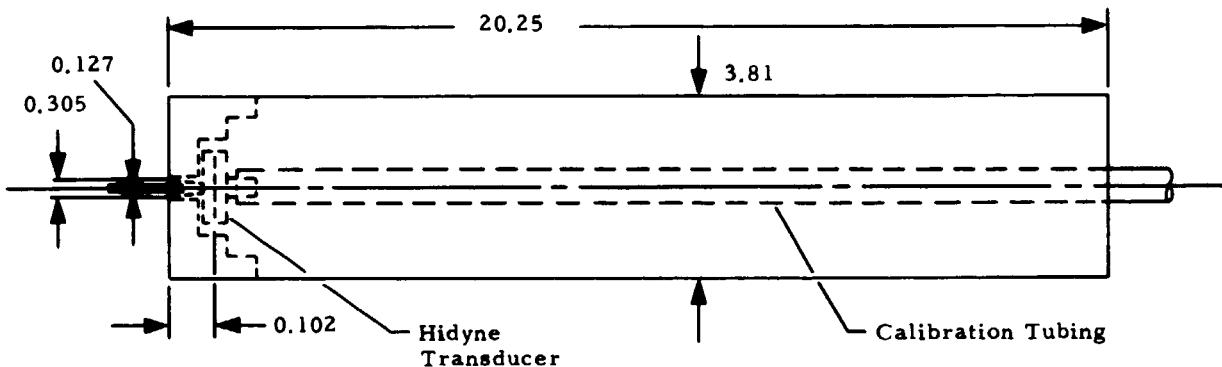


Fig. 5 - Schematic of Engine Hardware

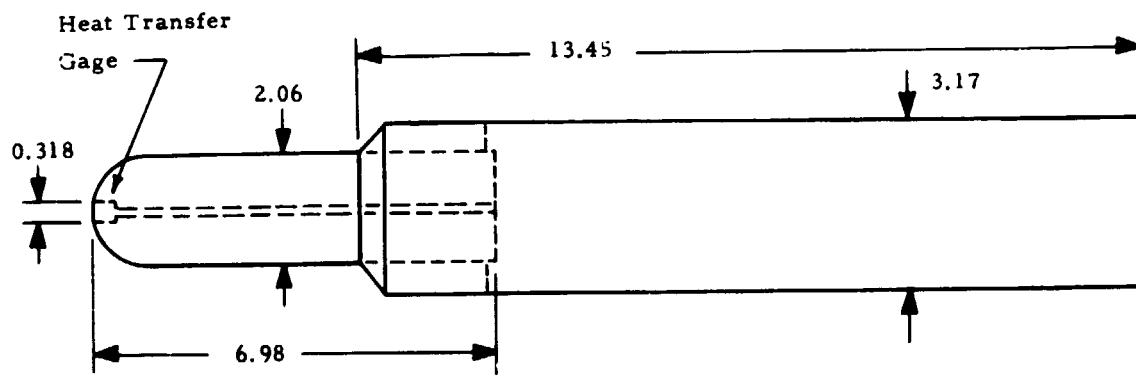


Probe A

All dimensions in centimeters



Probe B



Heat Transfer Probe

Fig. 6 - Schematic of Typical IBFF Probes

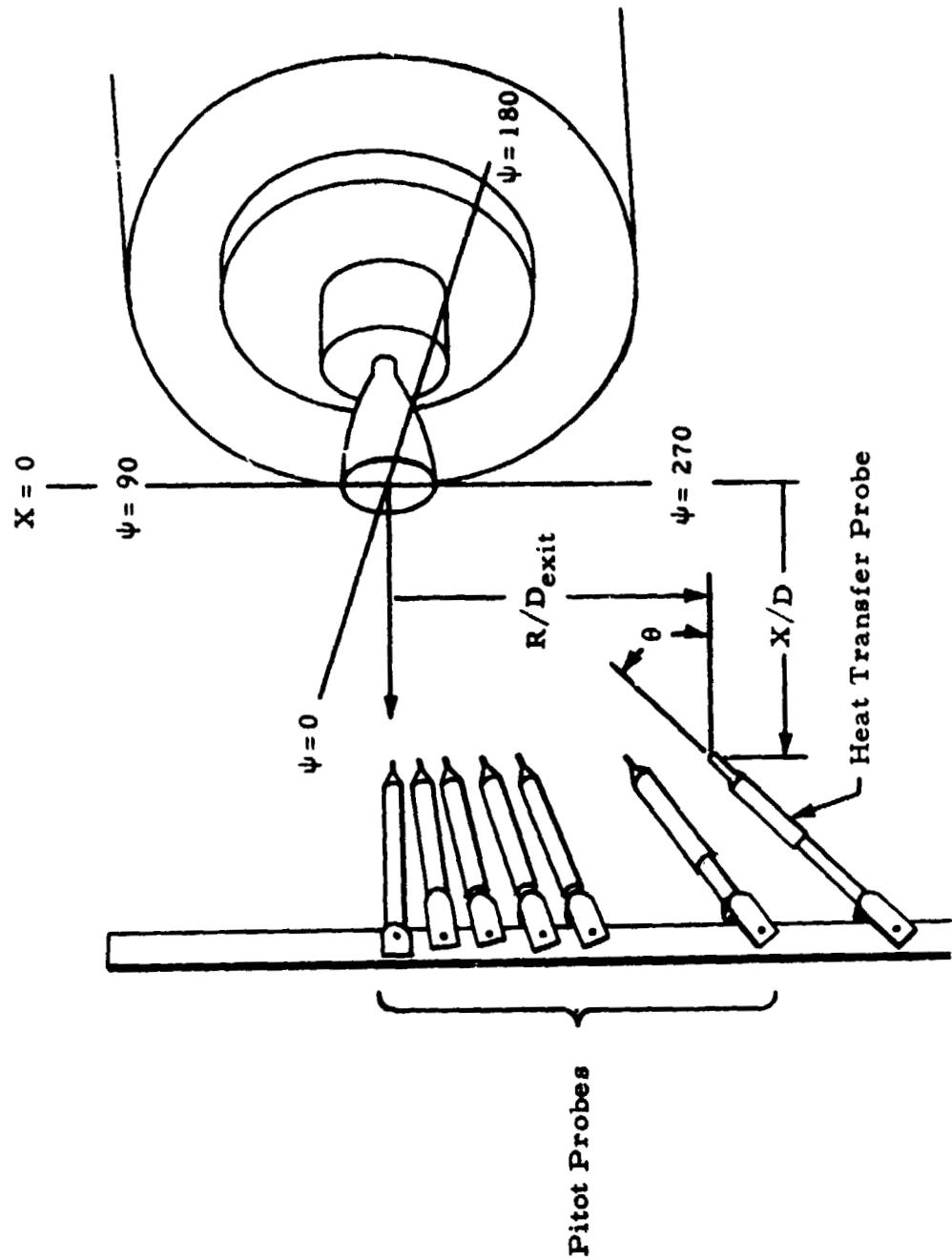


Fig. 7 - Nozzle/Impact Probe Axis System

LMSC-HREC D225839

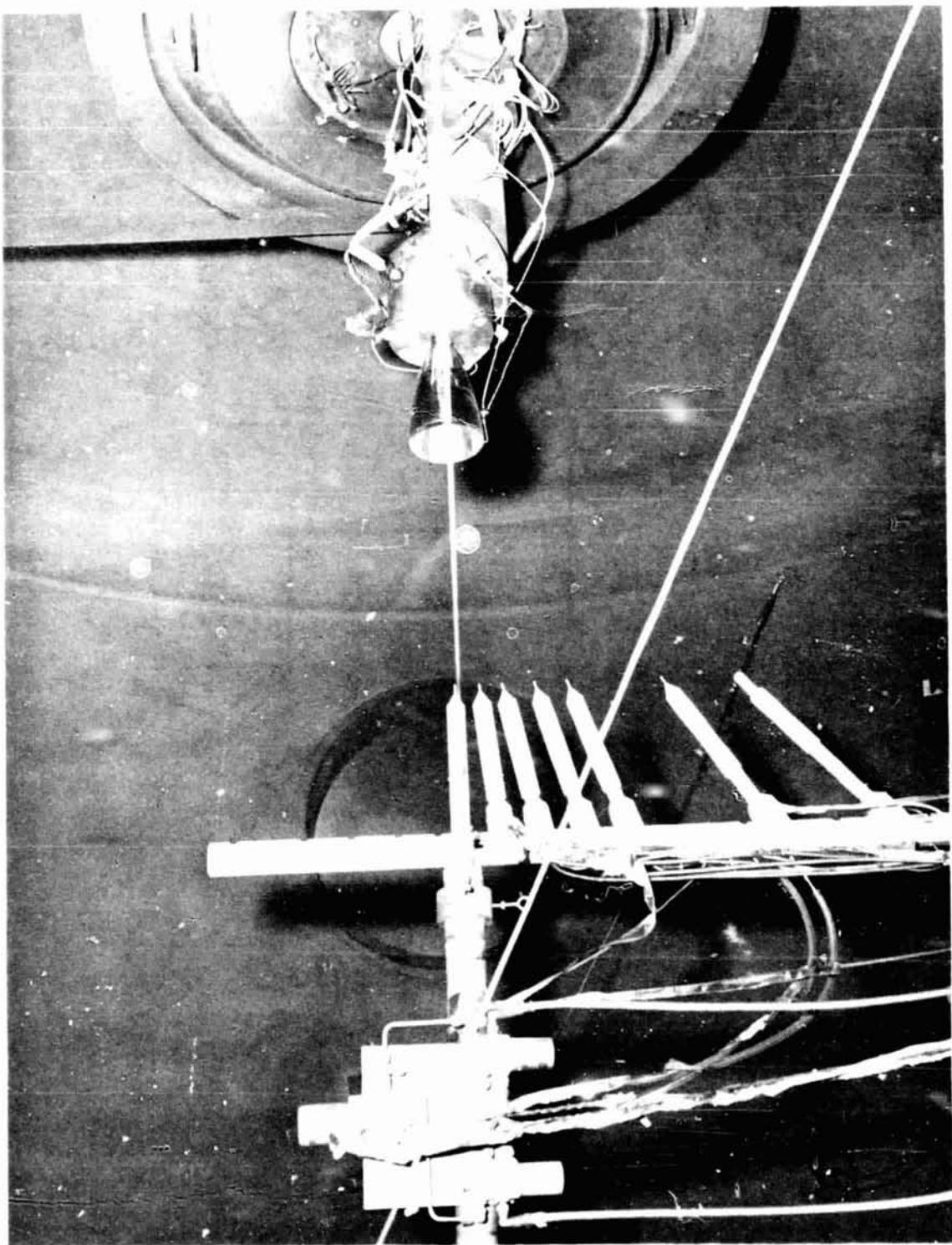


Fig. 8 - Equivalent Engine Plume Survey Arrangement

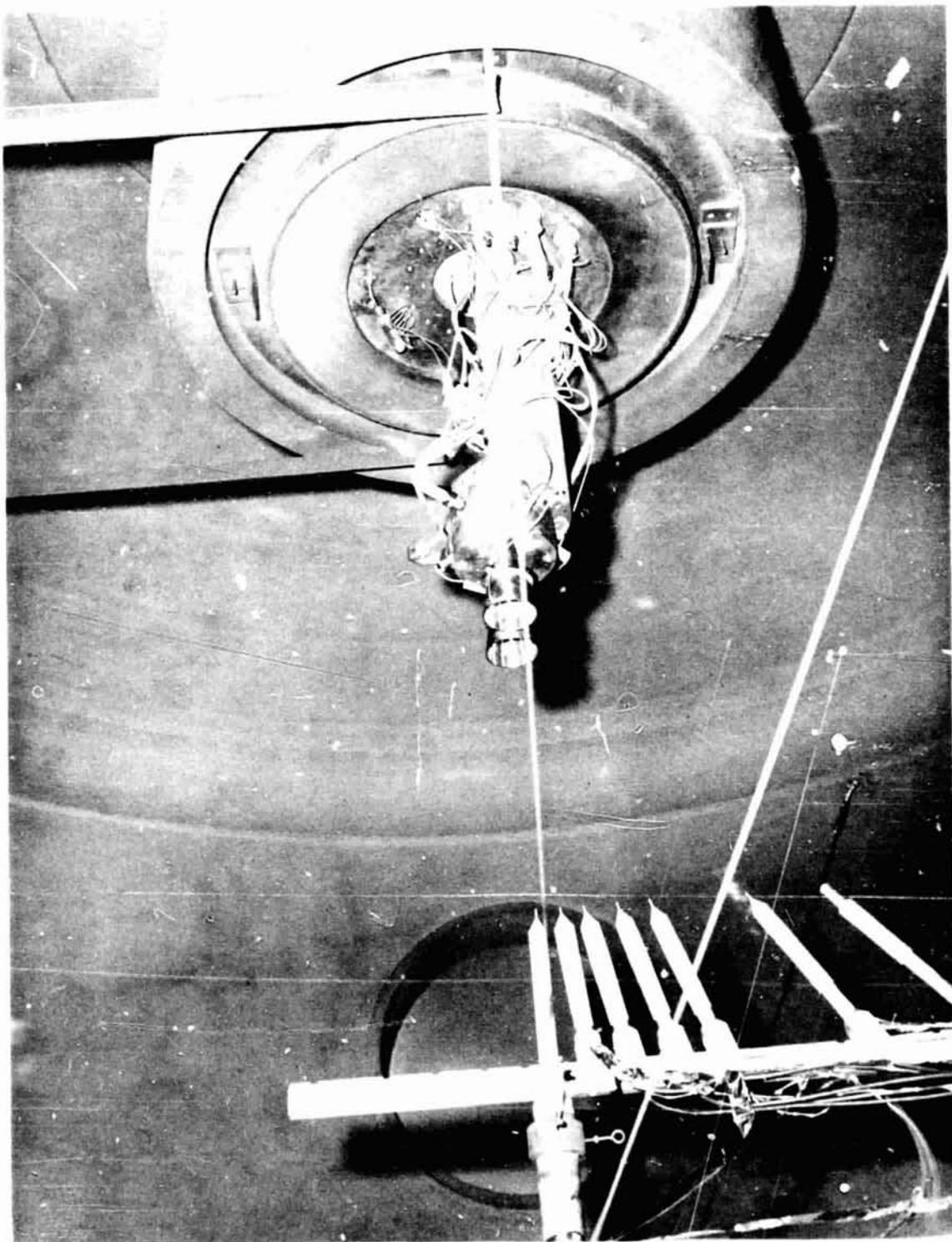


Fig. 9 - Dual Horizontal Configuration

PROCESSING PAGE BLANK NOT FILMED

LMSC-HREC D225839

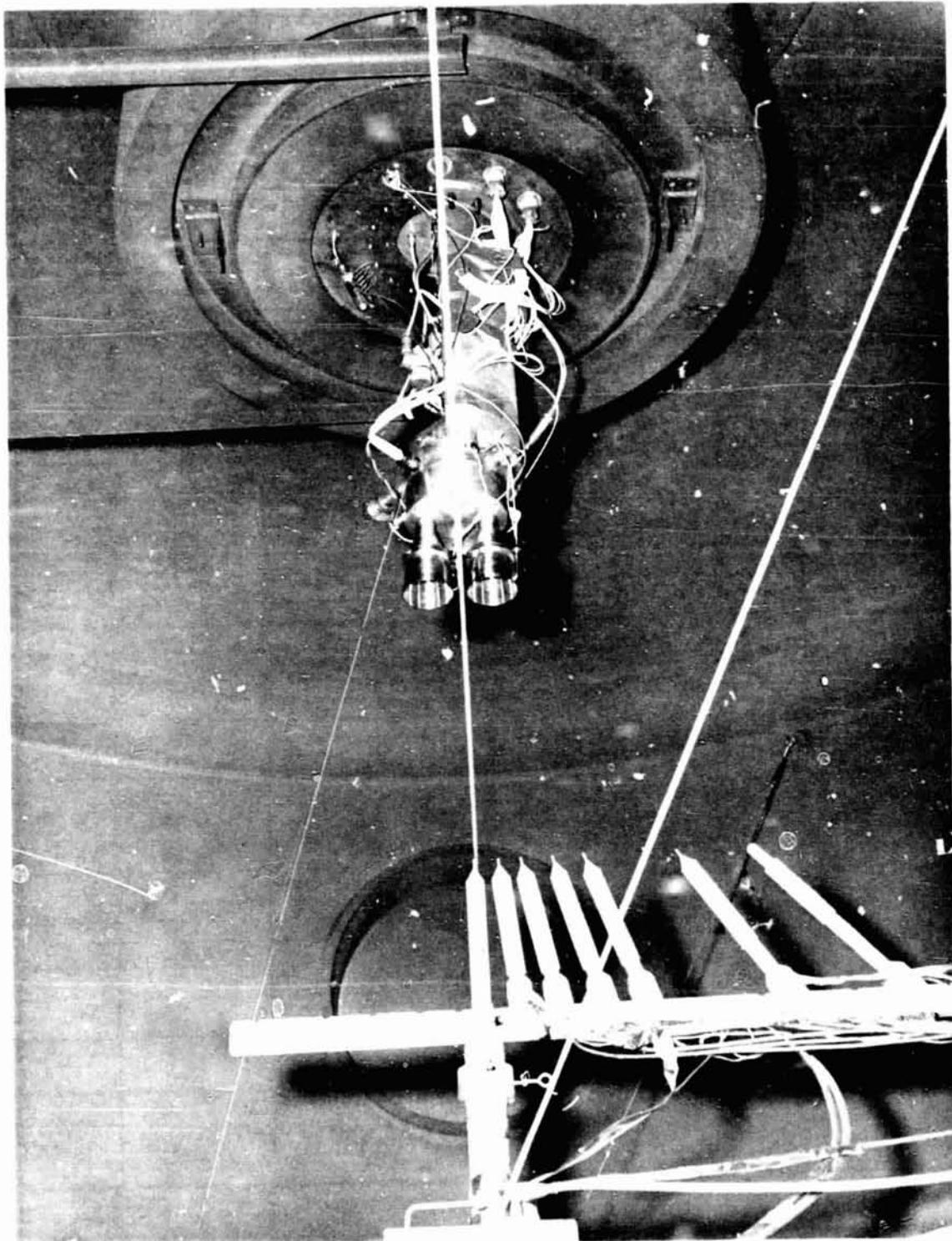


Fig. 10 - Dual Vertical Configuration

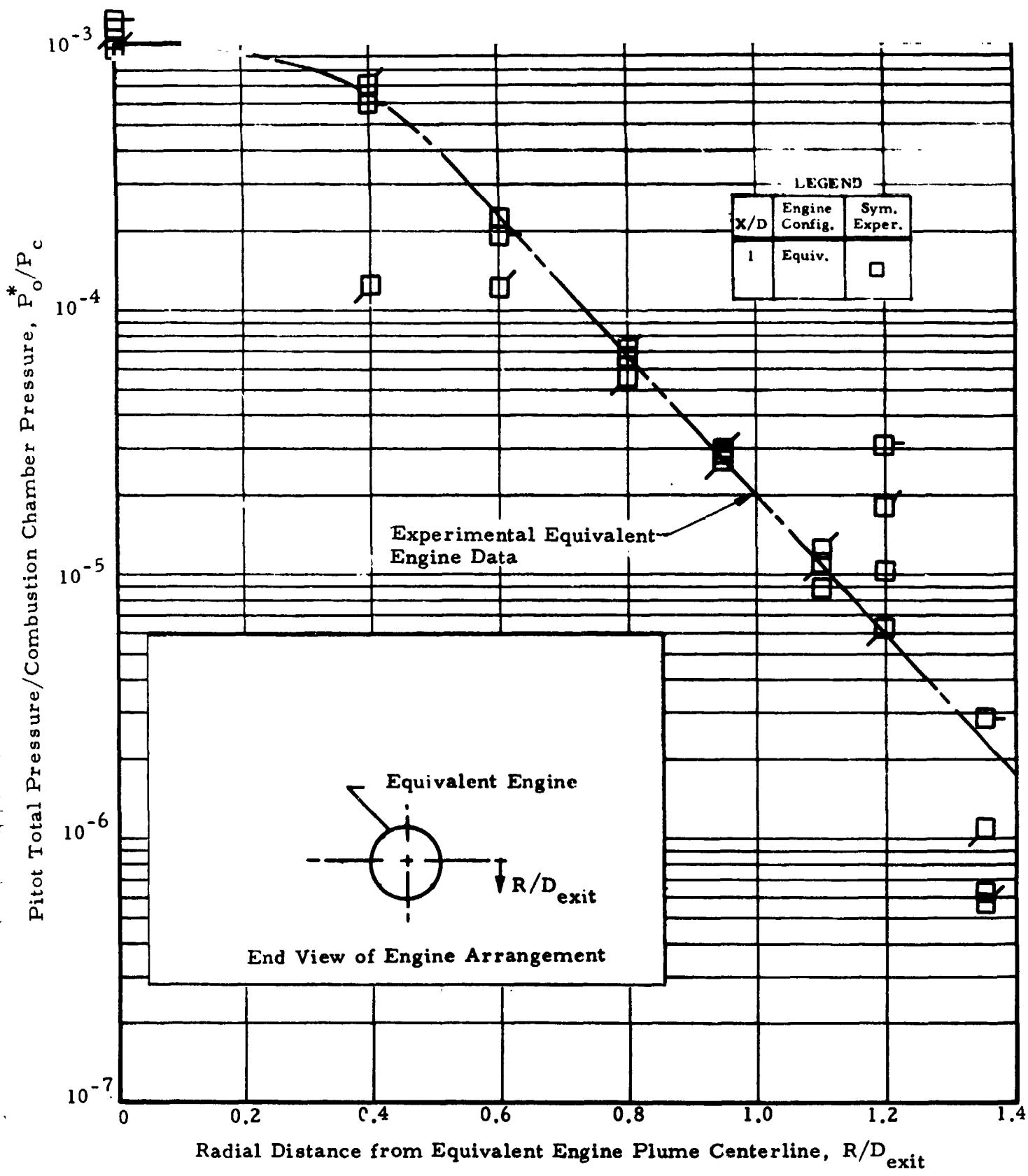


Fig. 11 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 1$ from the Engine Exit Plane (Equivalent Engine)

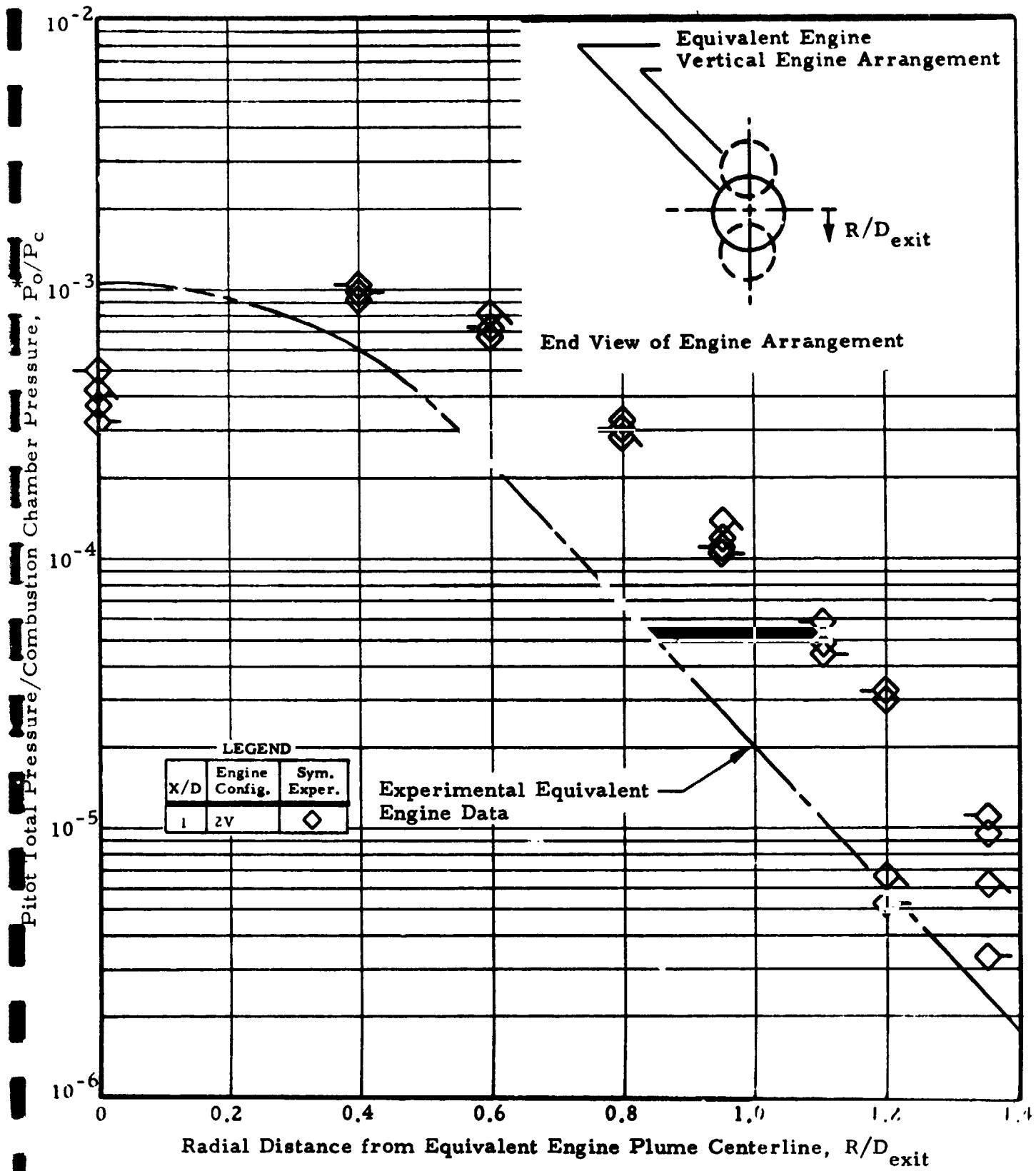


Fig. 12 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 1$ from the Engine Exit Plane (Vertical Engine Arrangement)

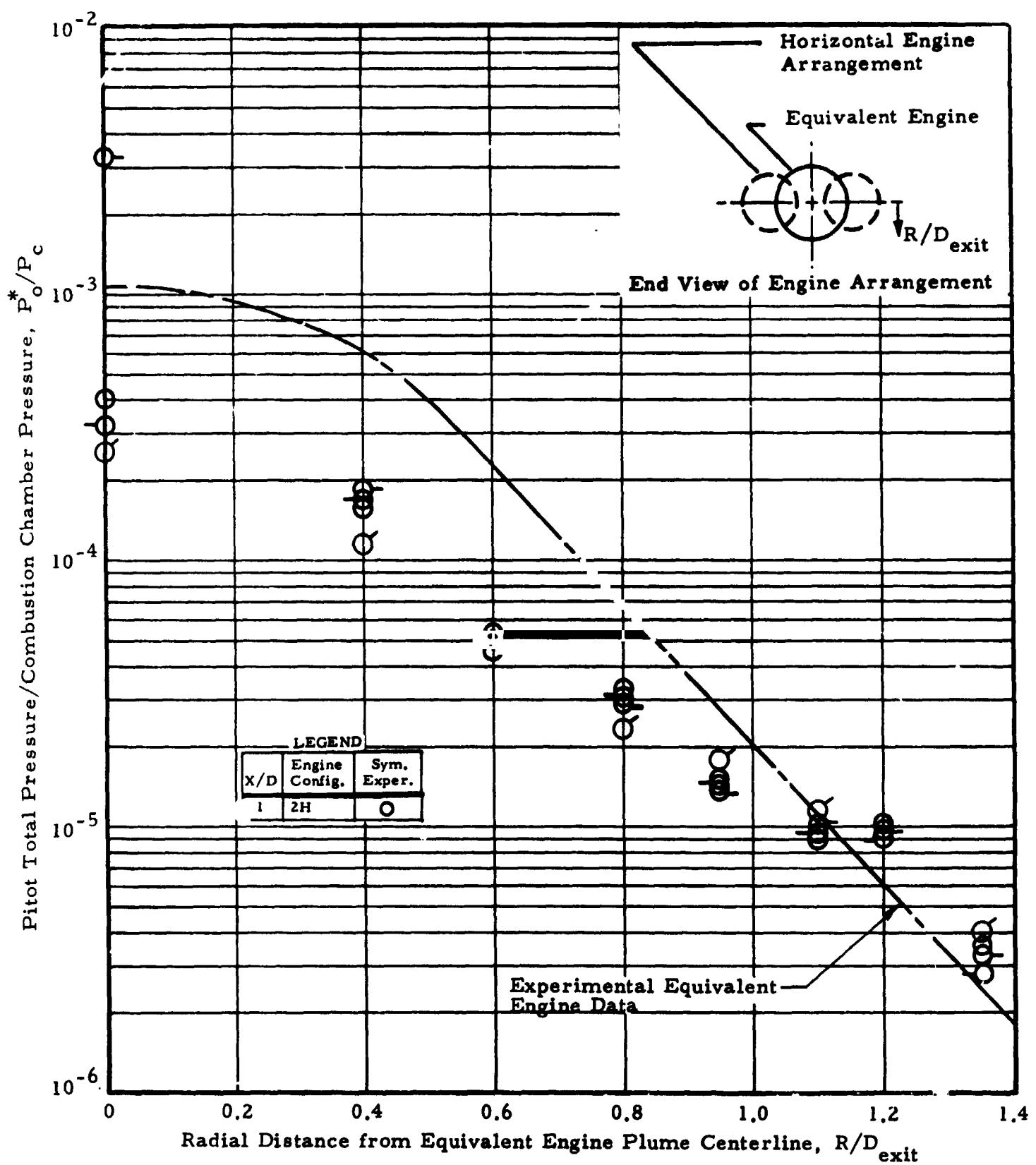


Fig. 13 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 1$ from the Engine Exit Plane (Horizontal Engine Arrangement)

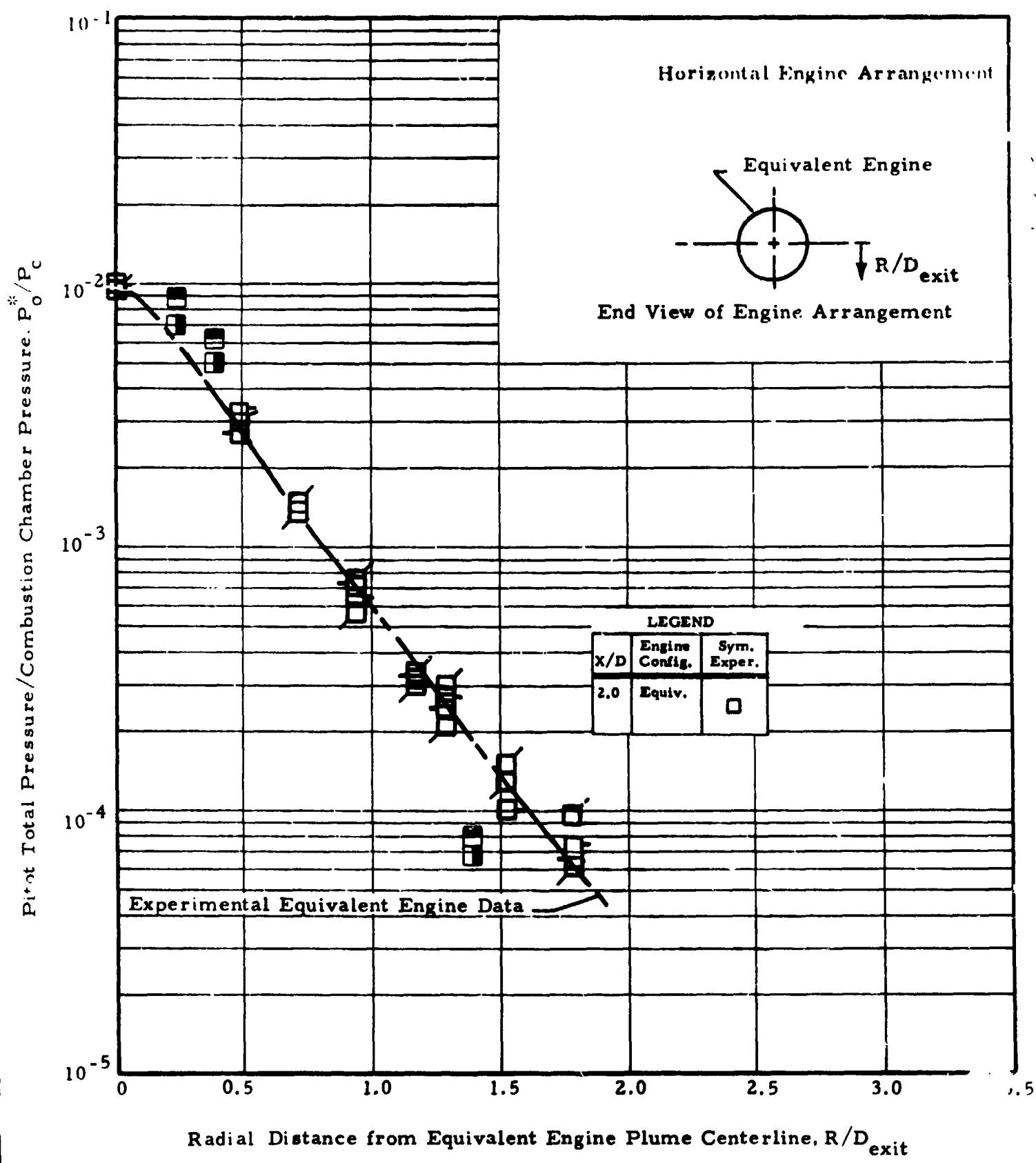


Fig. 14 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 2$ from the Engine Exit Plane (Equivalent Engine)

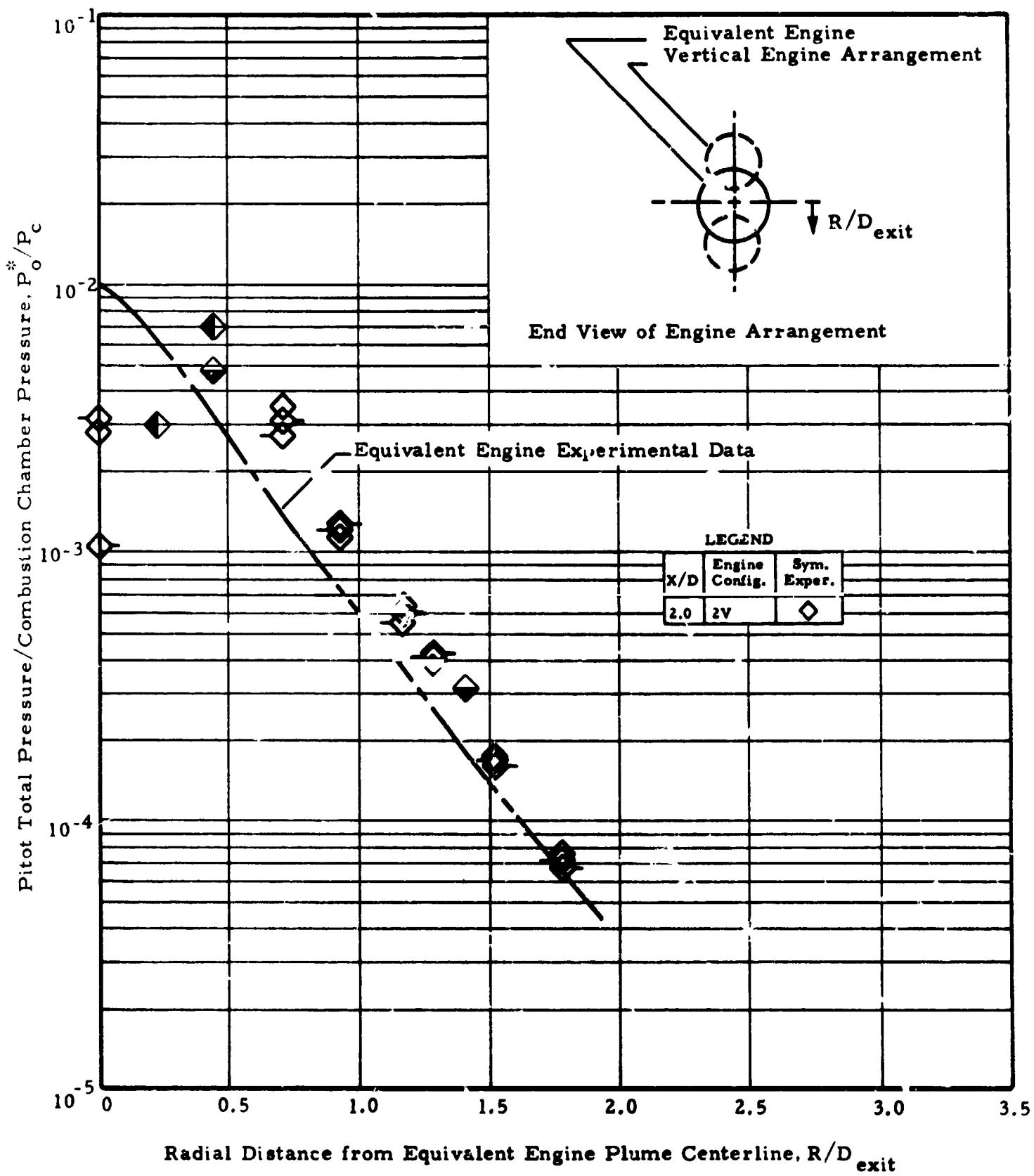


Fig. 15 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 2$ from the Engine Exit Plane (Vertical Engine Arrangement)

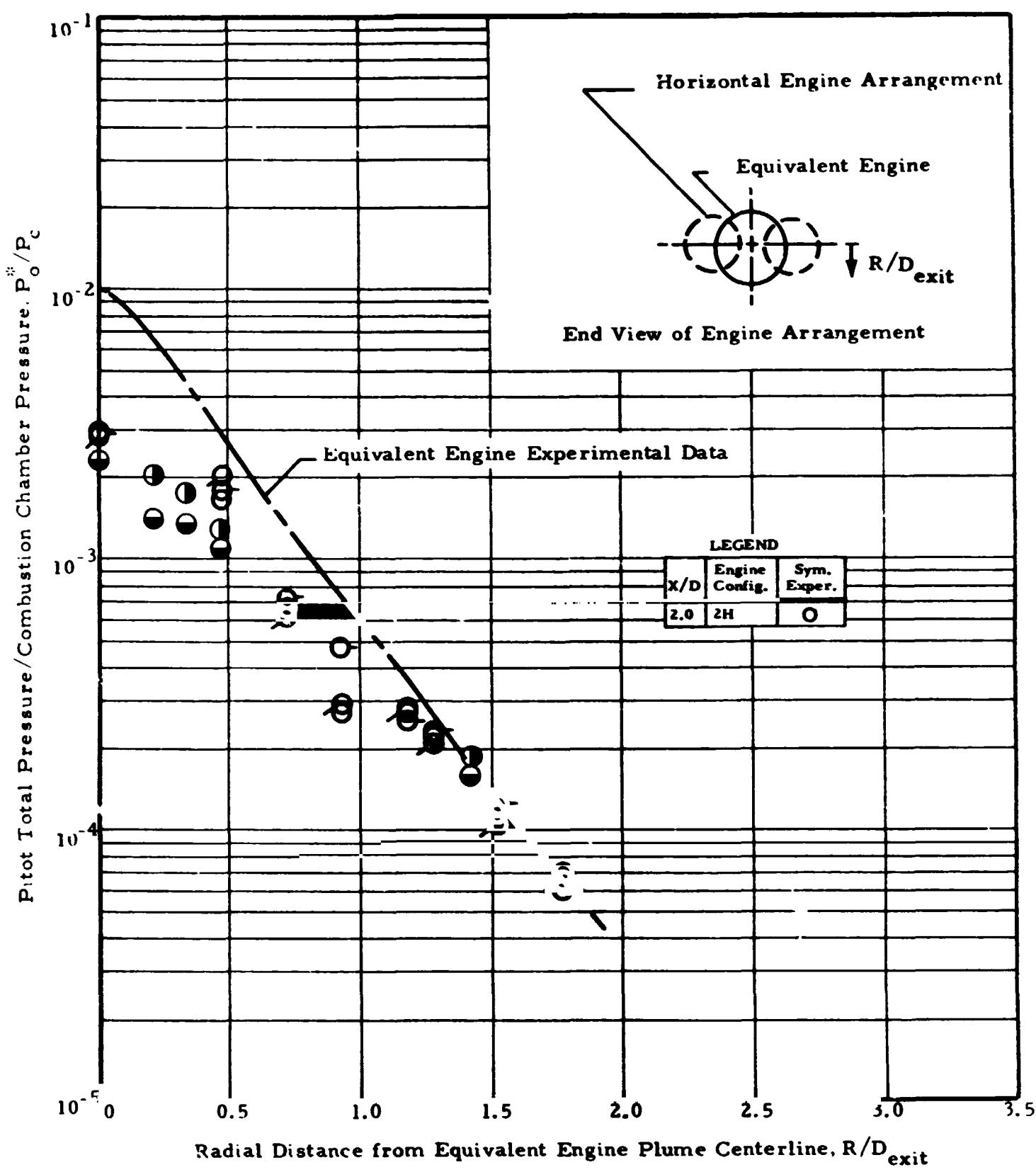


Fig. 16 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 2$ from the Engine Exit Plane (Horizontal Engine Arrangement)

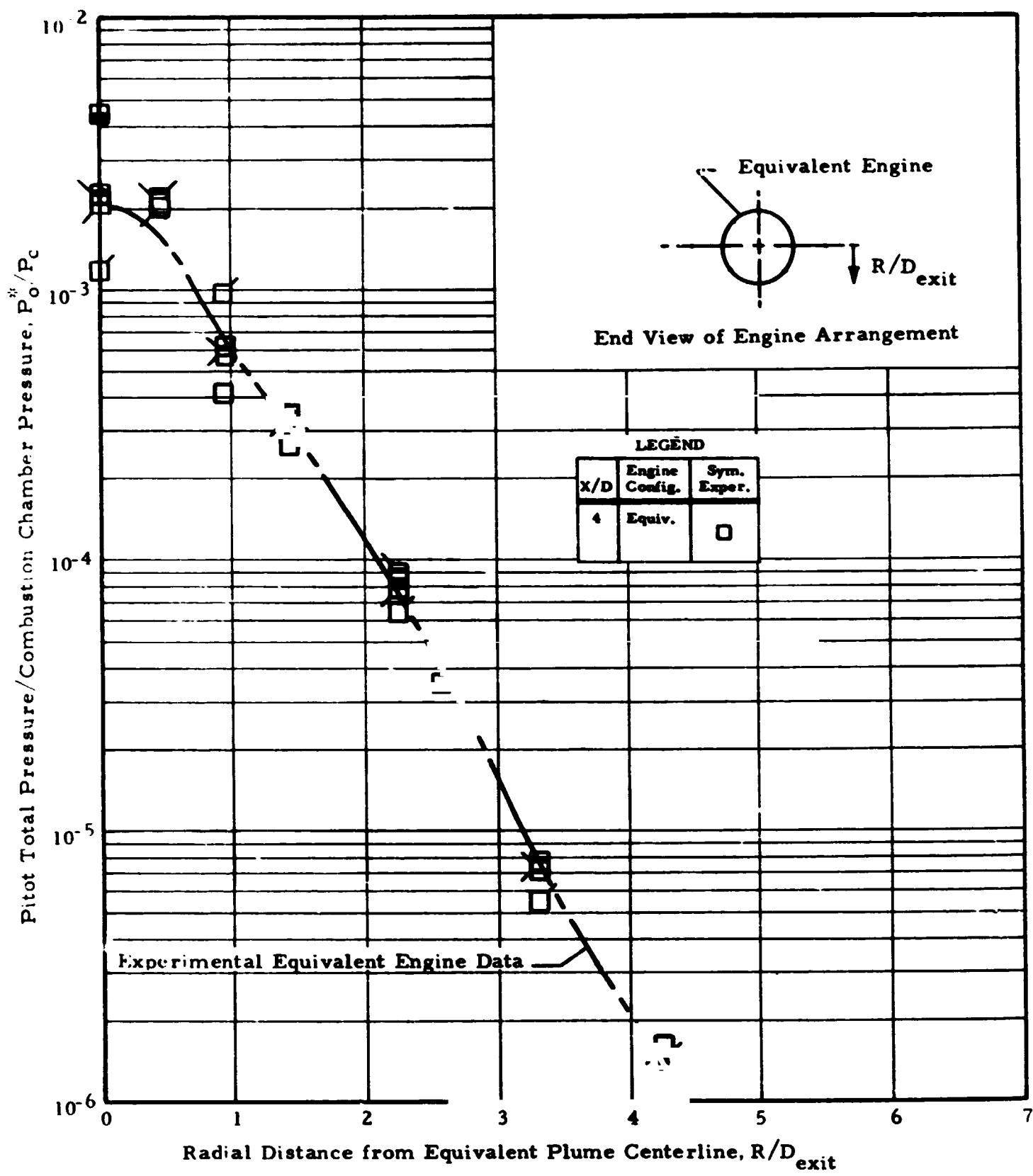


Fig. 17 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 4$ from the Engine Exit Plane (Equivalent Engine)

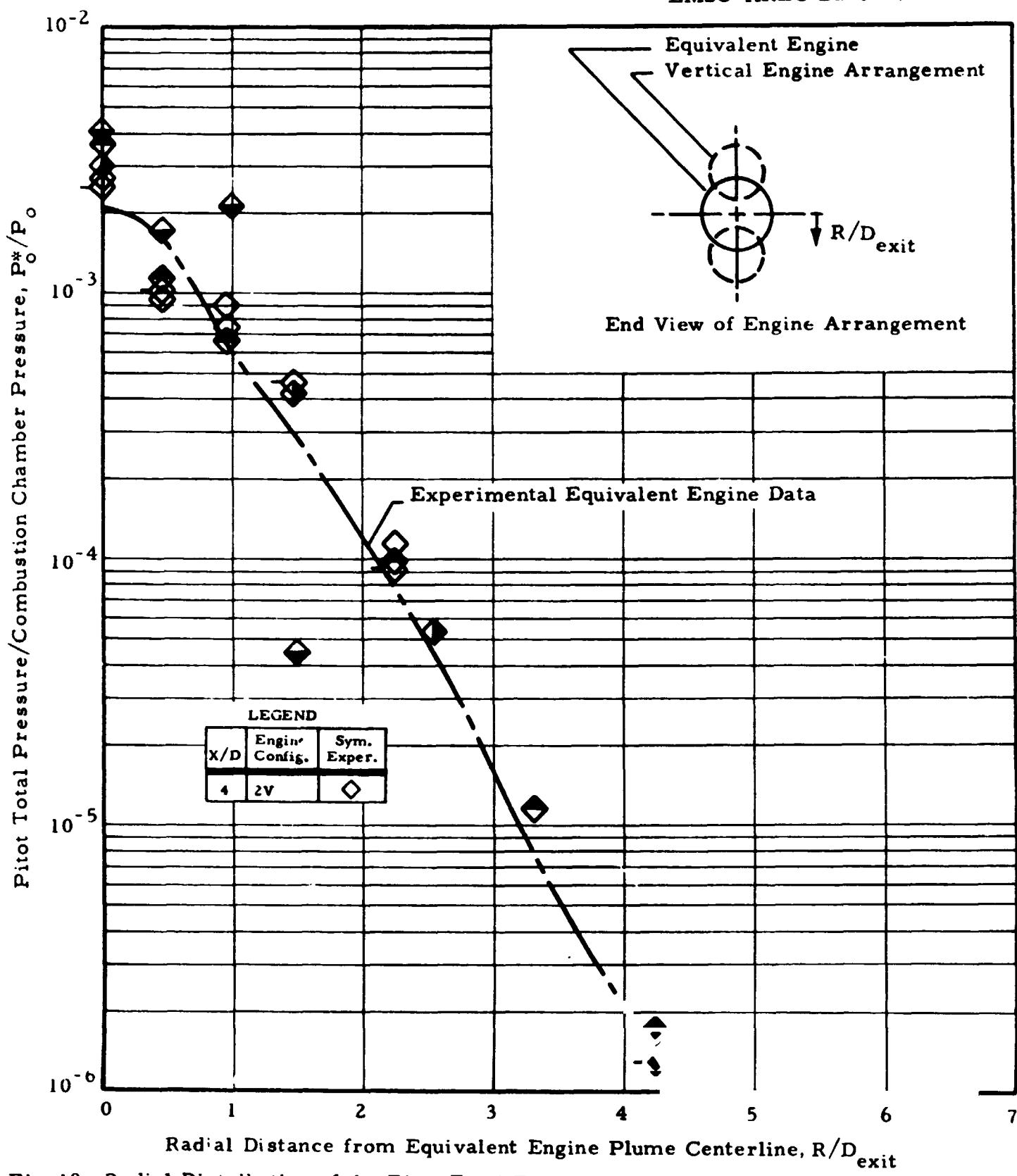


Fig. 18 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 4$ from the Engine Exit Plane (Vertical Engine Arrangement)

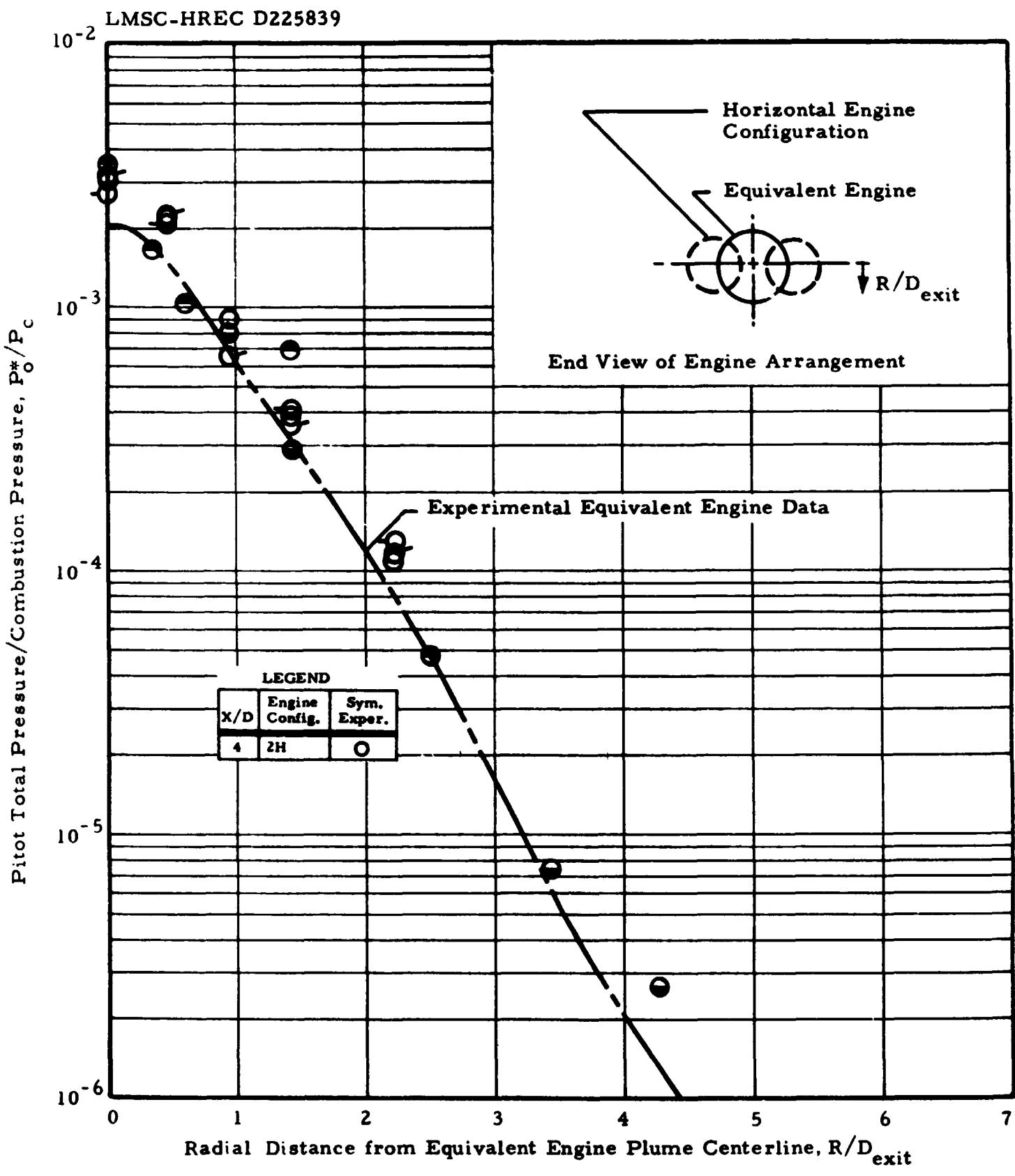


Fig. 19 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 4 from the Engine Exit Plane (Horizontal Engine Arrangement)

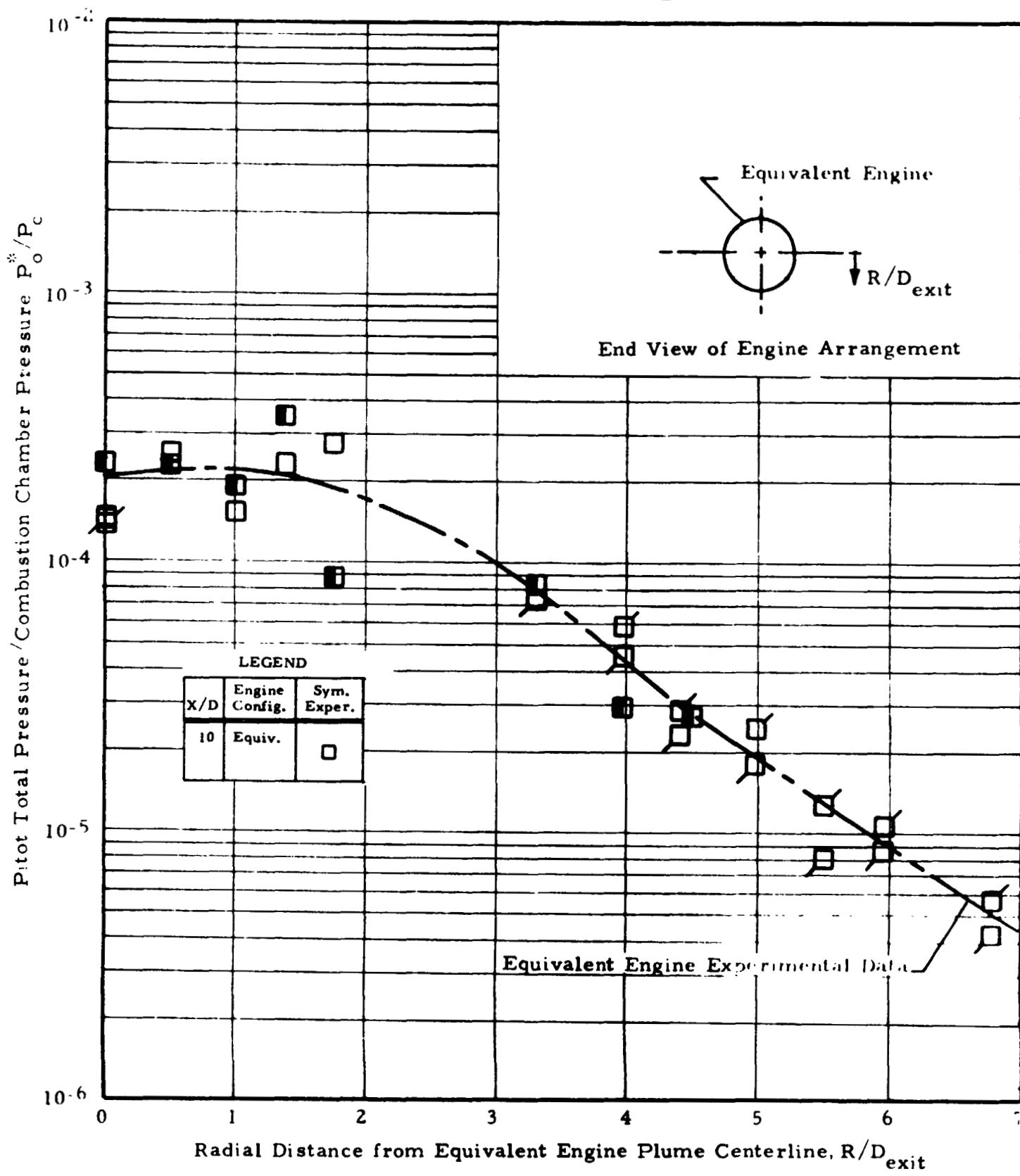


Fig. 20 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 10$ from the Engine Exit Plane (Equivalent Engine)

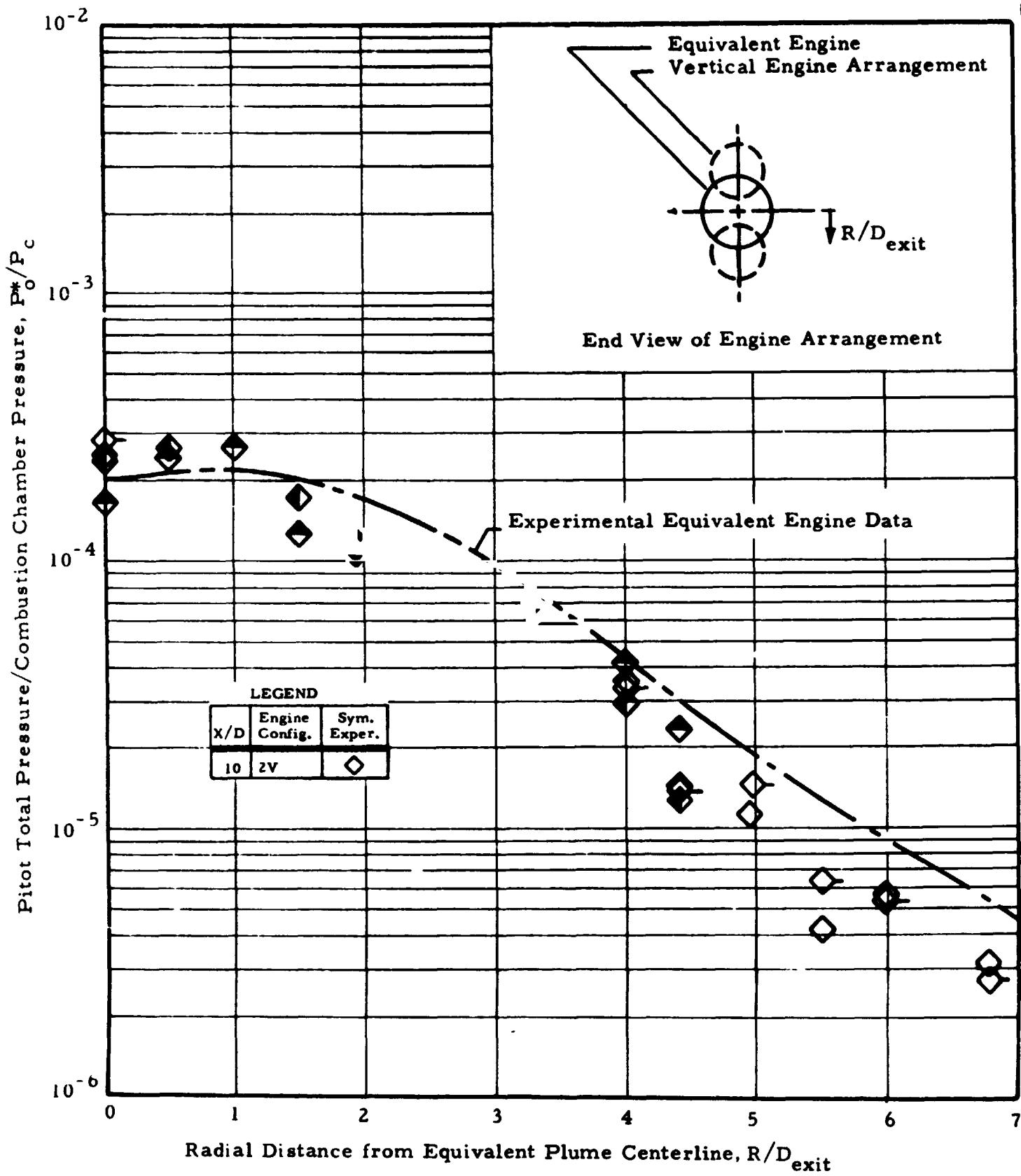


Fig. 21 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 10$ from the Engine Exit Plane (Vertical Engine Arrangement)

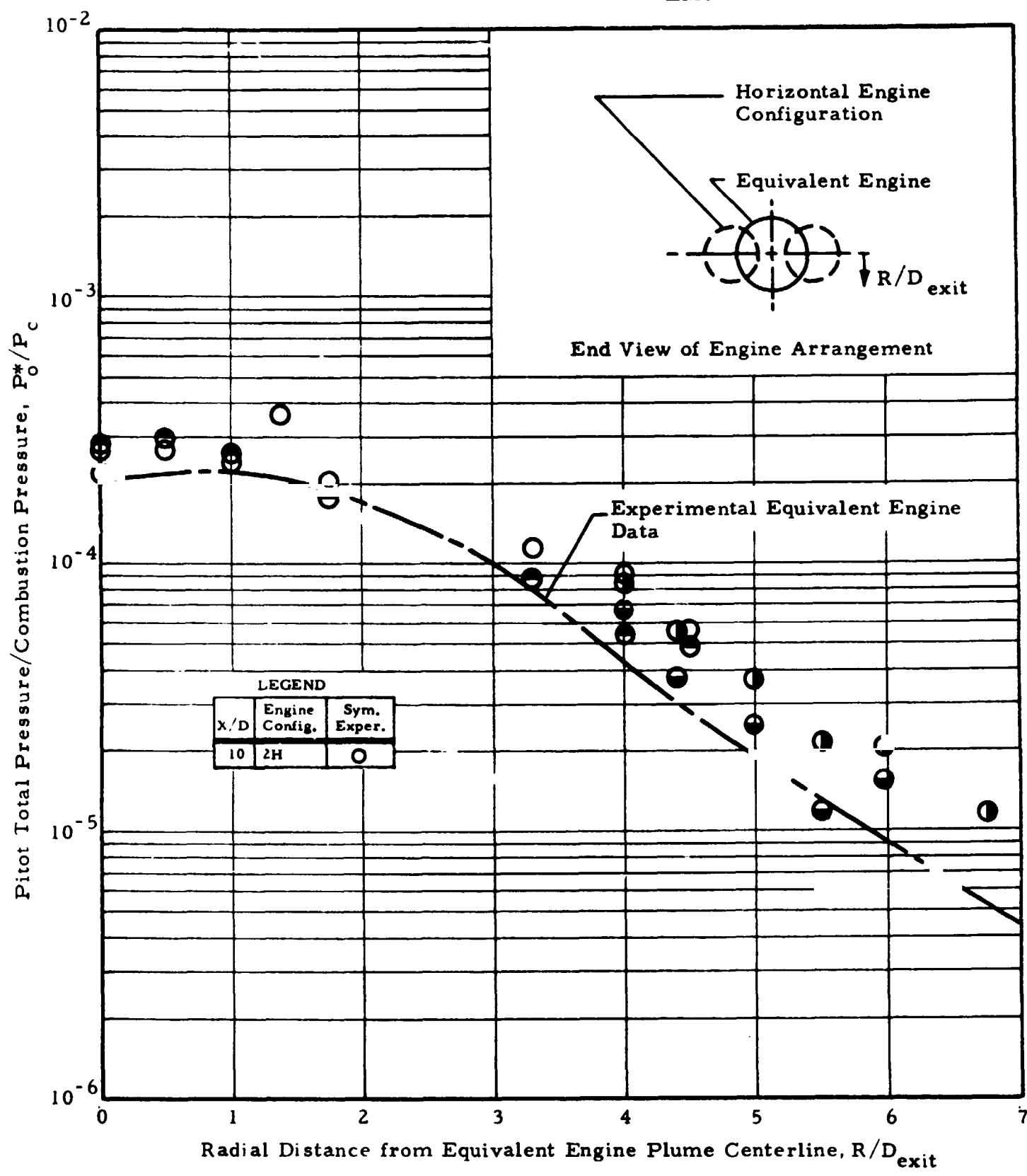


Fig. 22 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 10$ from the Engine Exit Plane (Horizontal Engine Arrangement)

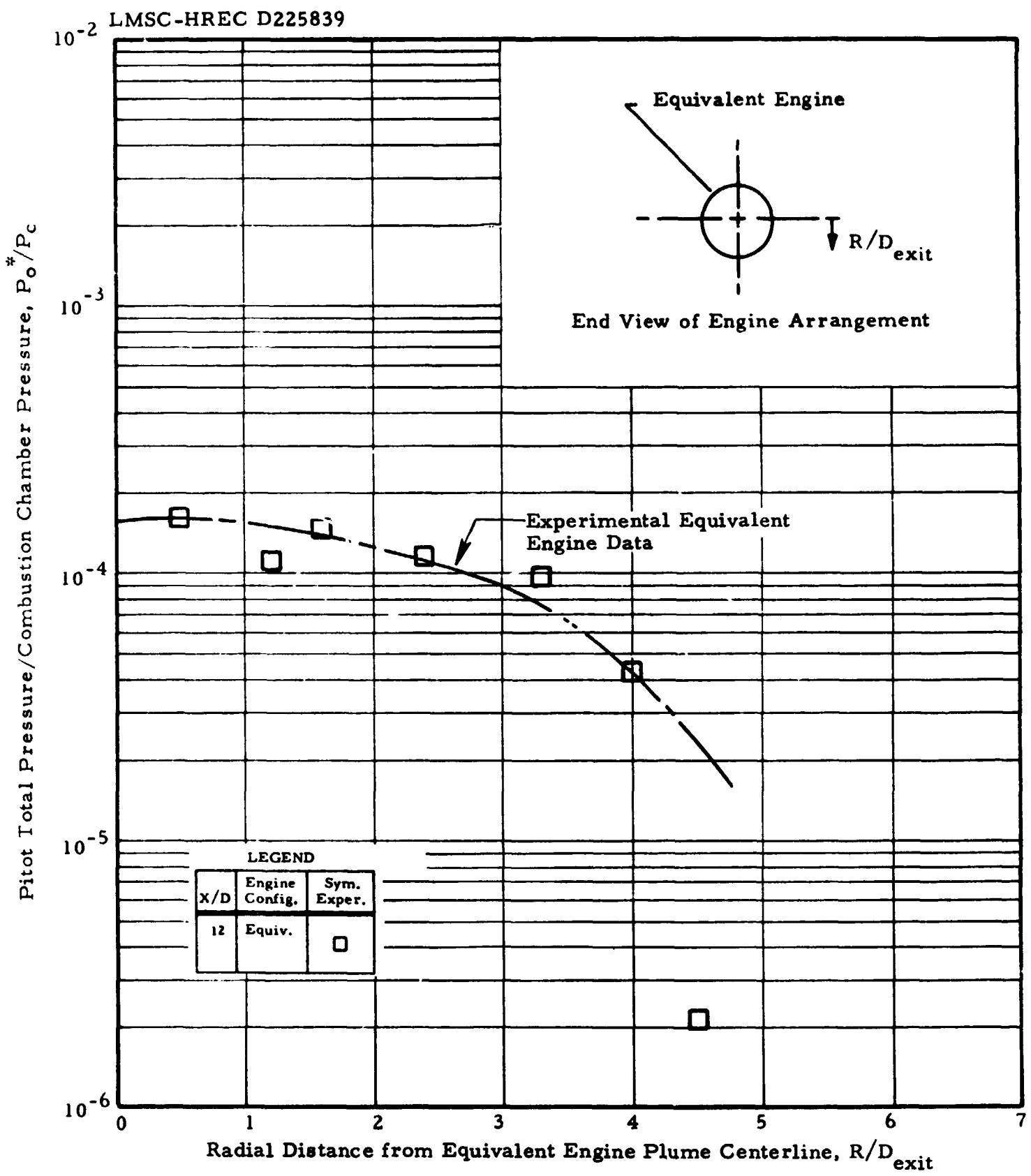


Fig. 23 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 12$ from the Engine Exit Plane (Equivalent Engine)

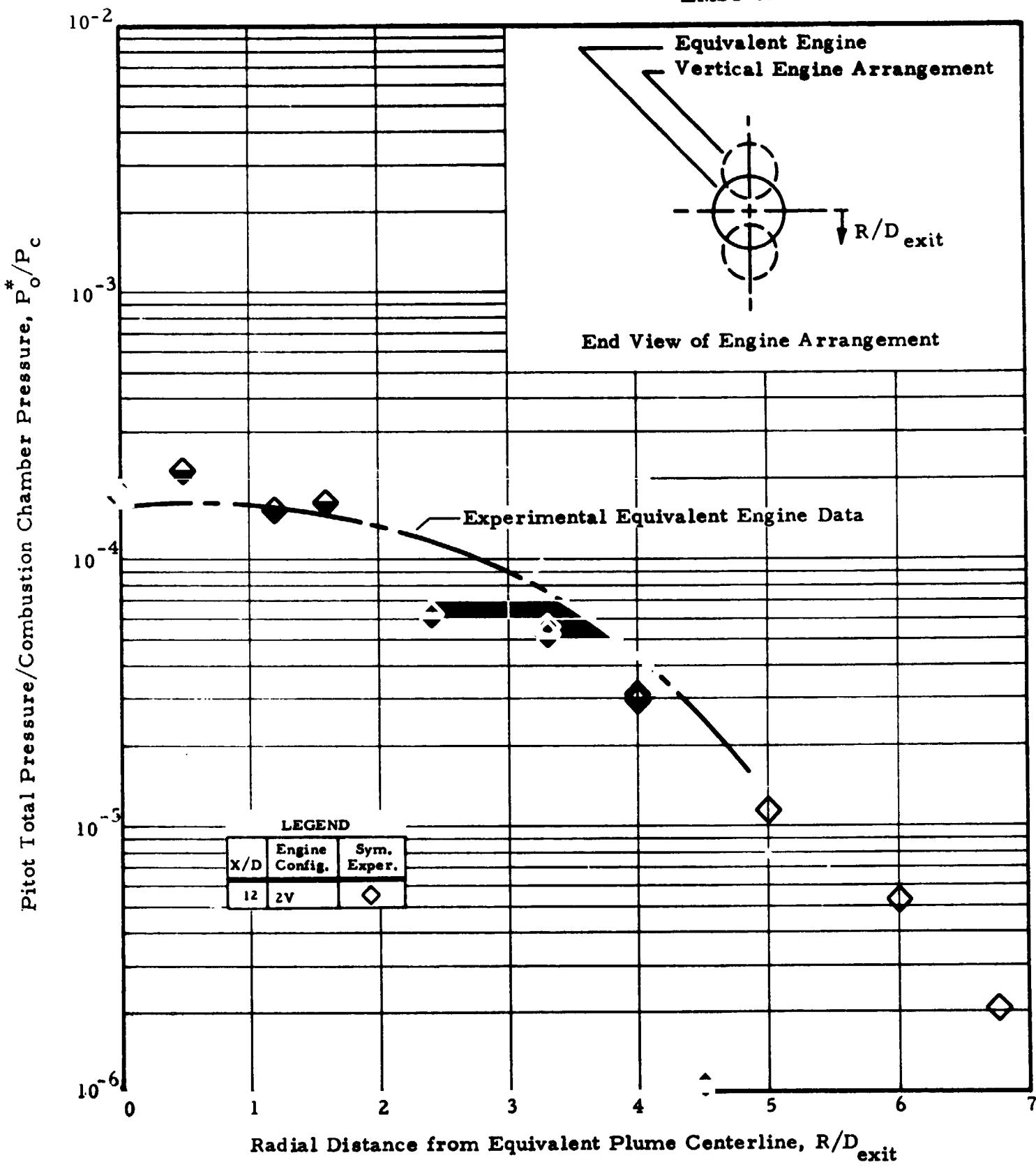


Fig. 24 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 12$ from the Engine Exit Plane (Vertical Engine Arrangement)

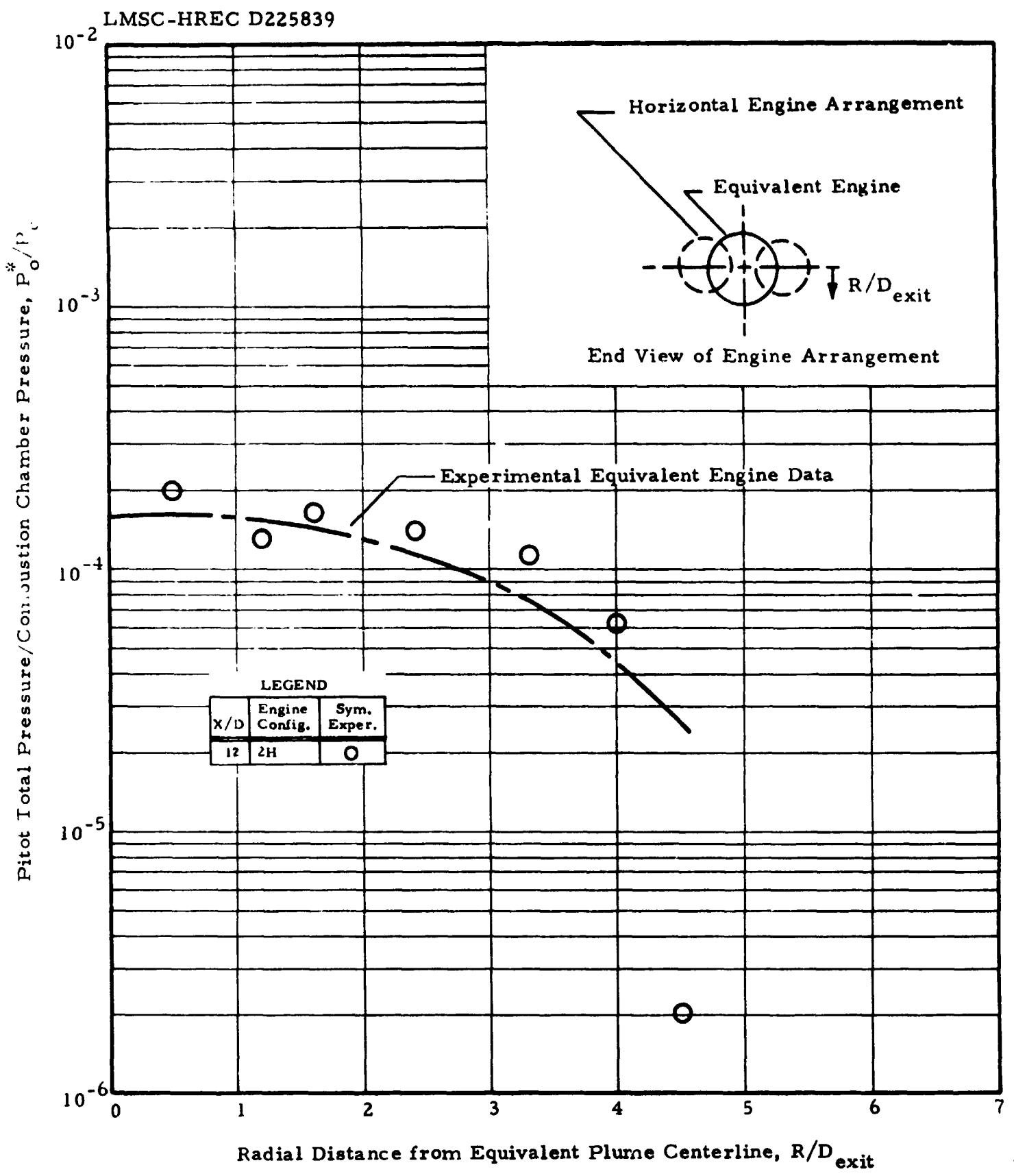


Fig. 25 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 12$ from the Engine Exit Plane (Horizontal Engine Arrangement)

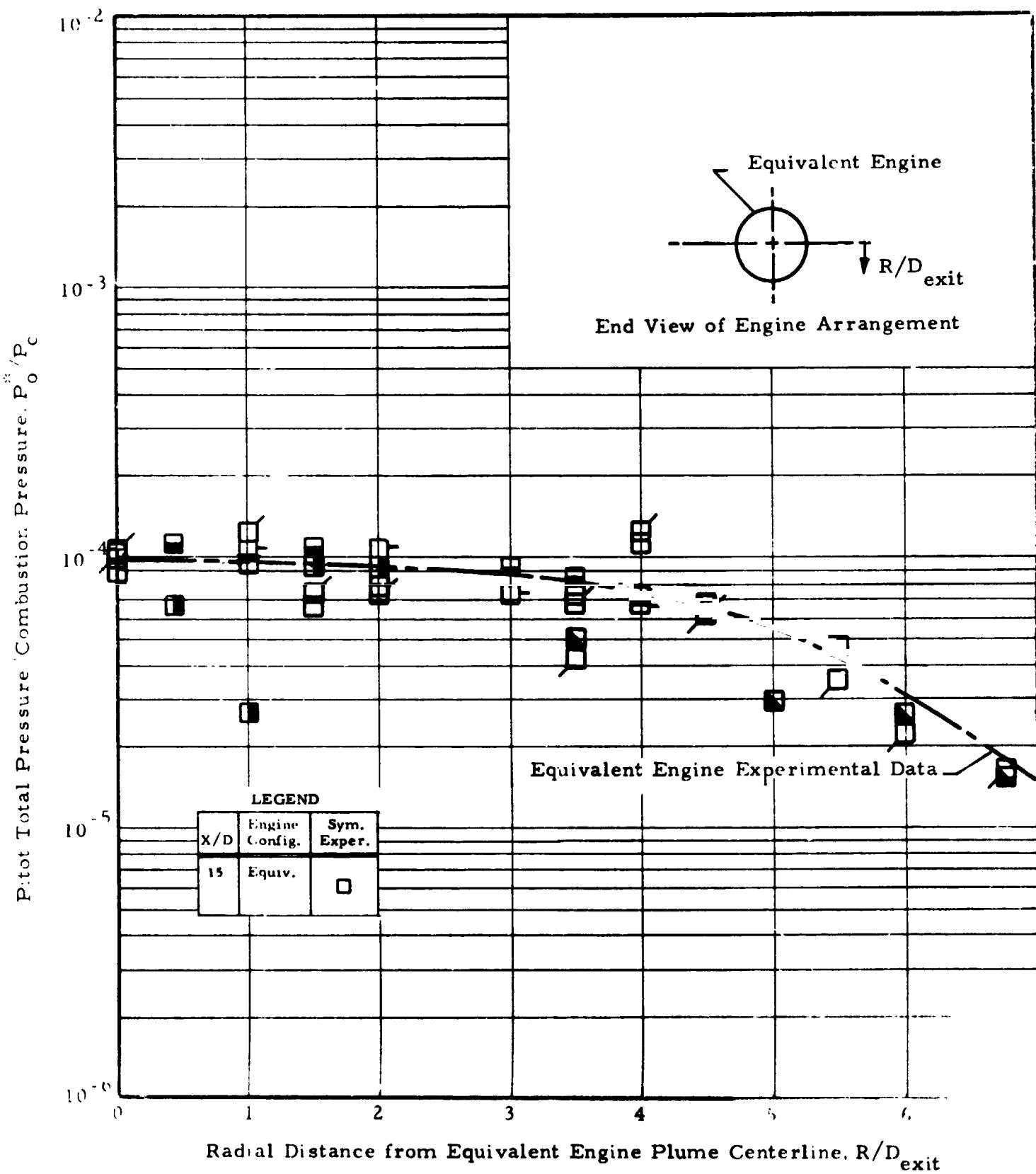


Fig. 26 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 15$ from the Engine Exit Plane (Equivalent Engine)

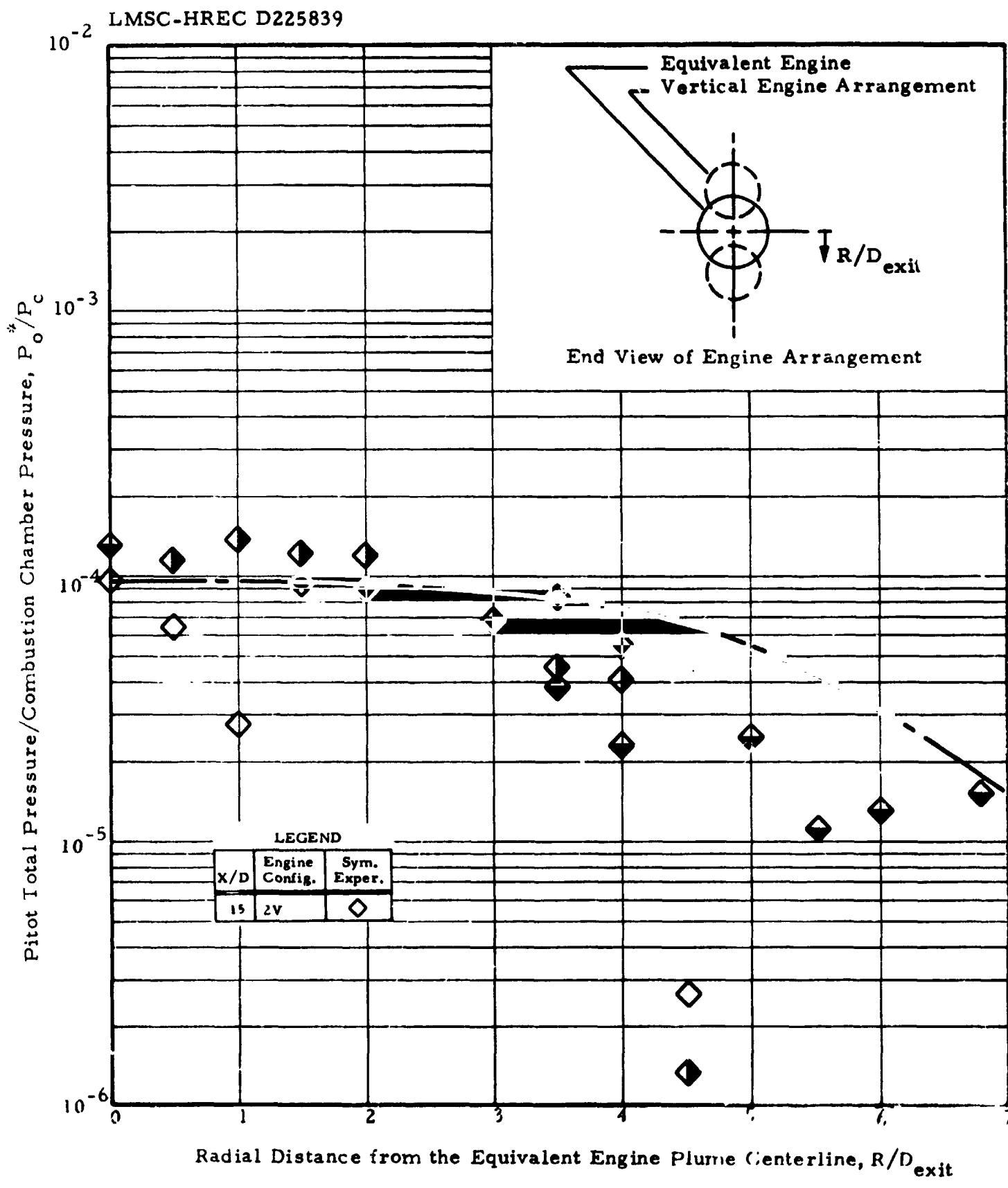


Fig. 27 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at $X/D = 15$ from the Engine Exit Plane (Vertical Engine Arrangement)

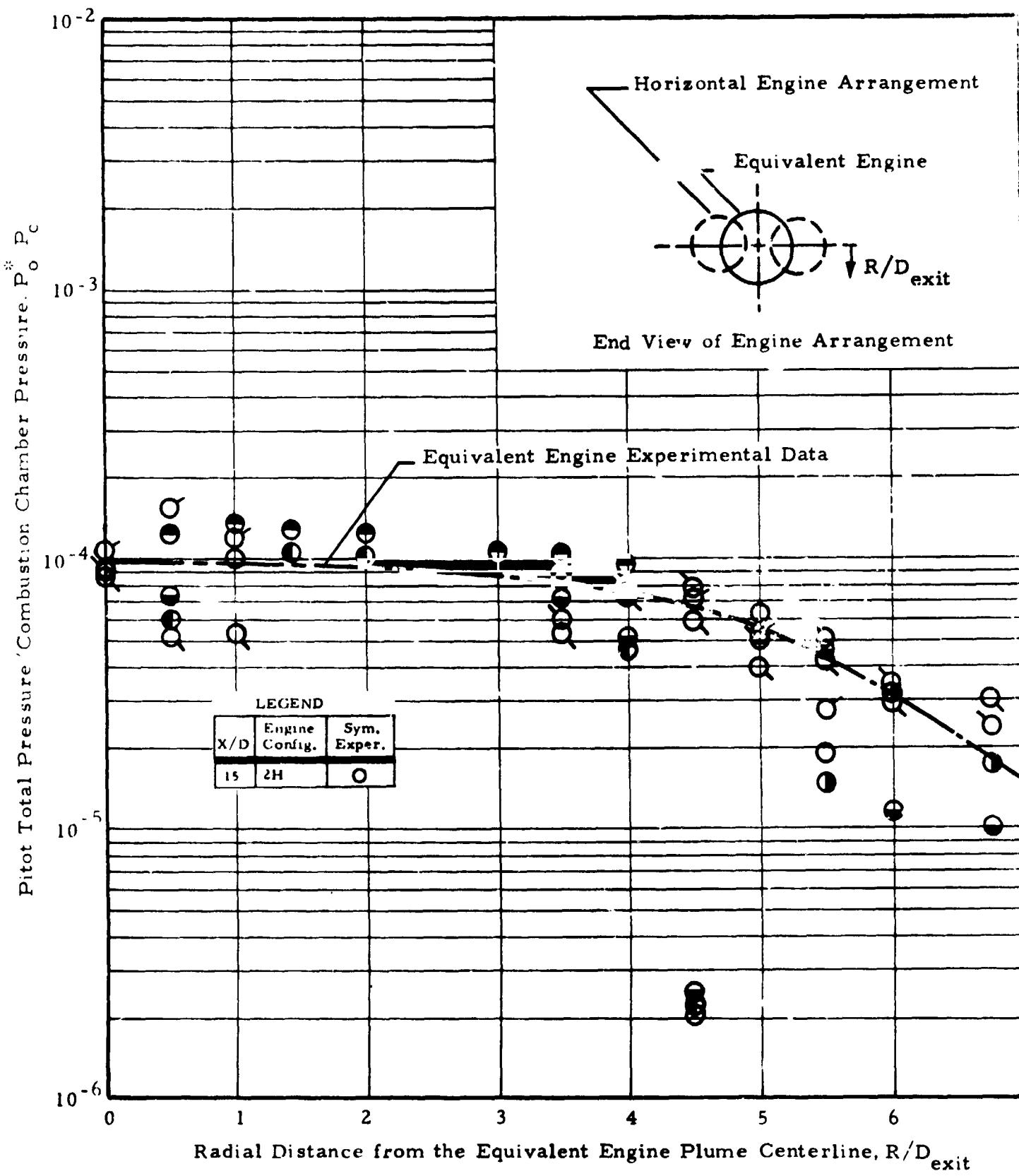


Fig. 28 - Radial Distribution of the Pitot Total Pressure in the Orbiter Main Engine Exhaust Plume at X/D = 15 from the Engine Exit Plane (Horizontal Engine Arrangement)

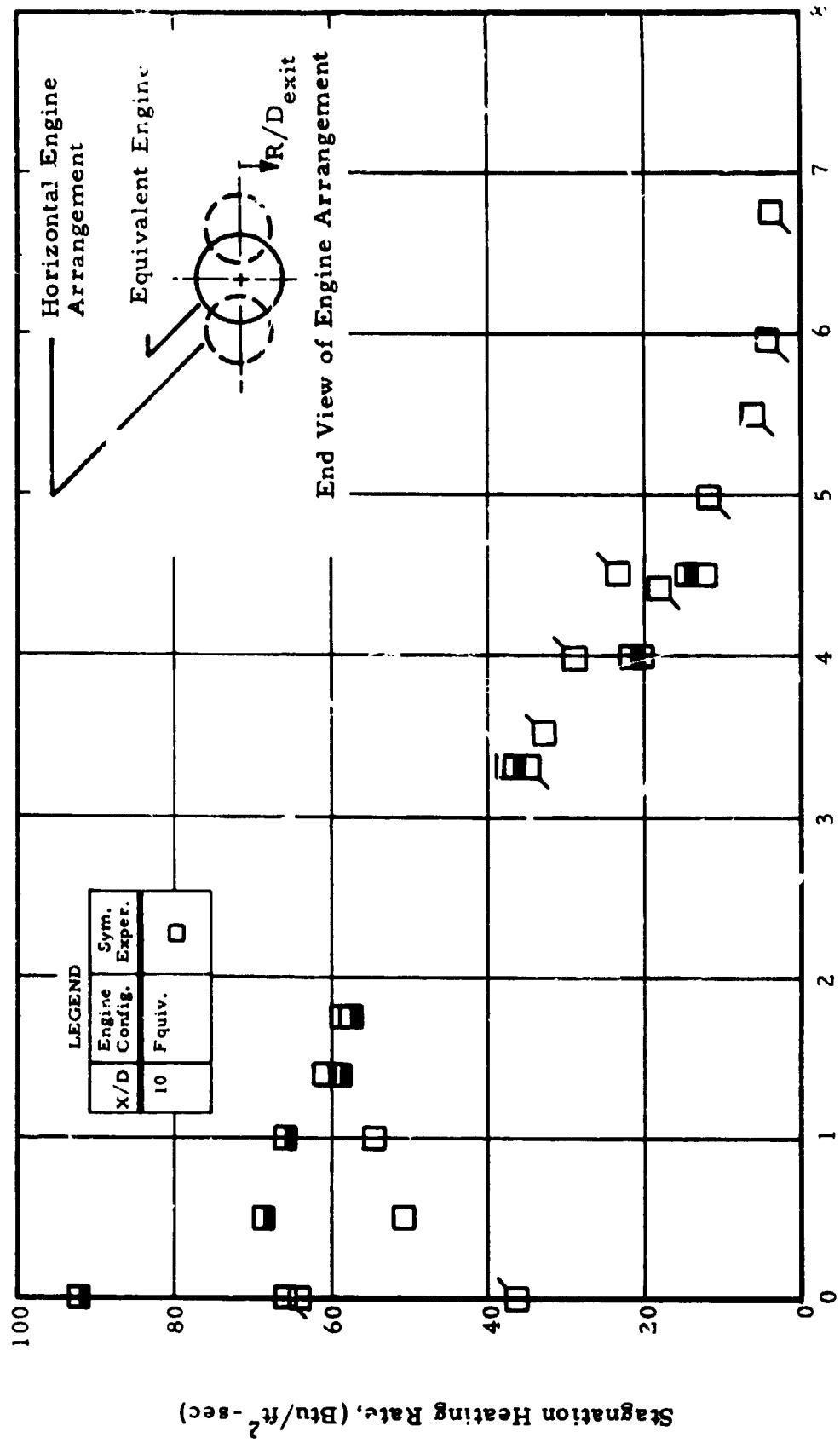
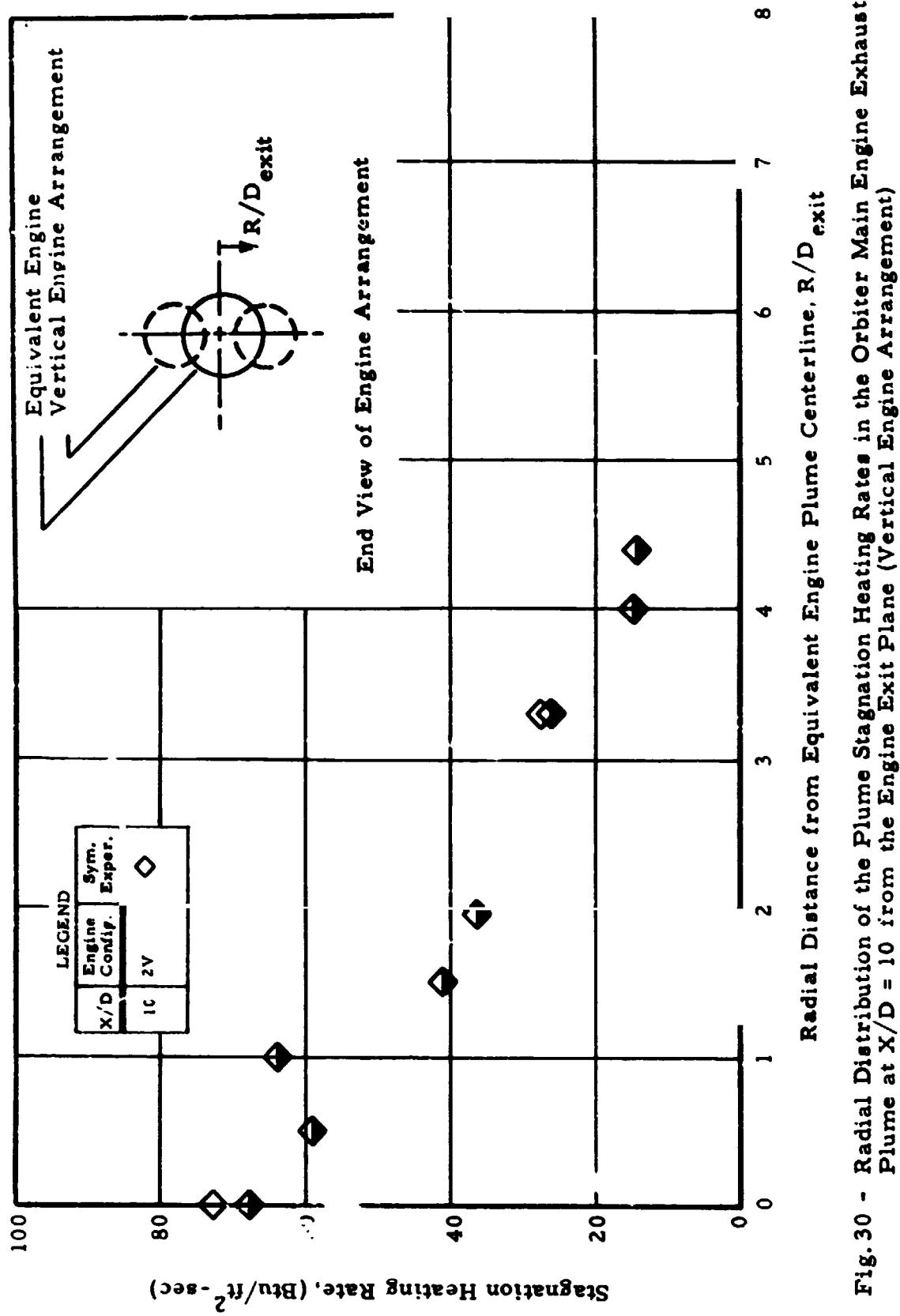


Fig. 29 - Radial Distribution of the Plume Stagnation Heating Rates in the Orbiter Main Engine Exhaust Plume at $X/D = 10$ from the Engine Exit Plane (Equivalent Main Engine)



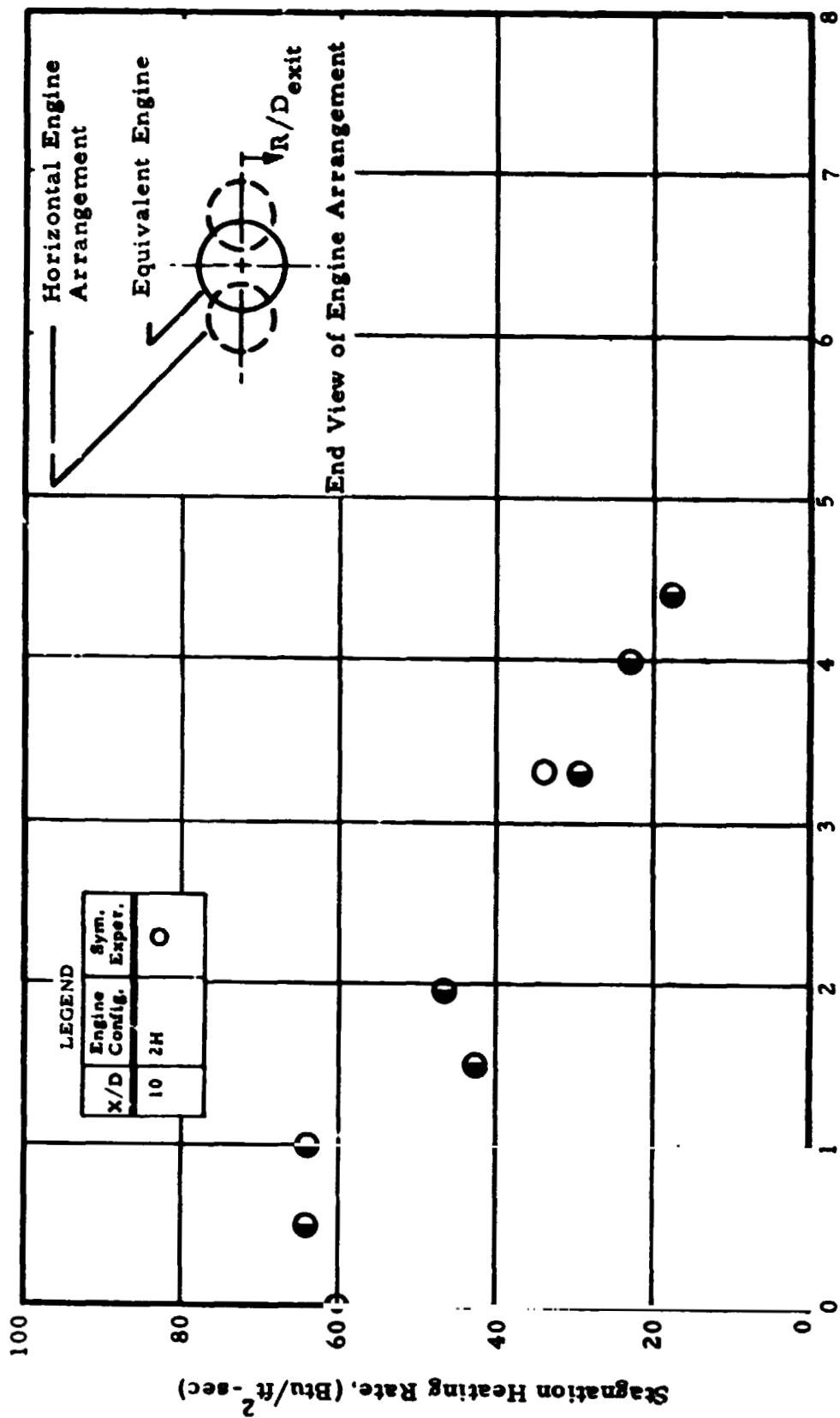


Fig. 31 - Radial Distribution of the Plume Stagnation Heating Rate in the Orbiter Main Engine Exhaust Plume at $X/D = 10$ from the Engine Exit Plane (Horizontal Engine Arrangement)

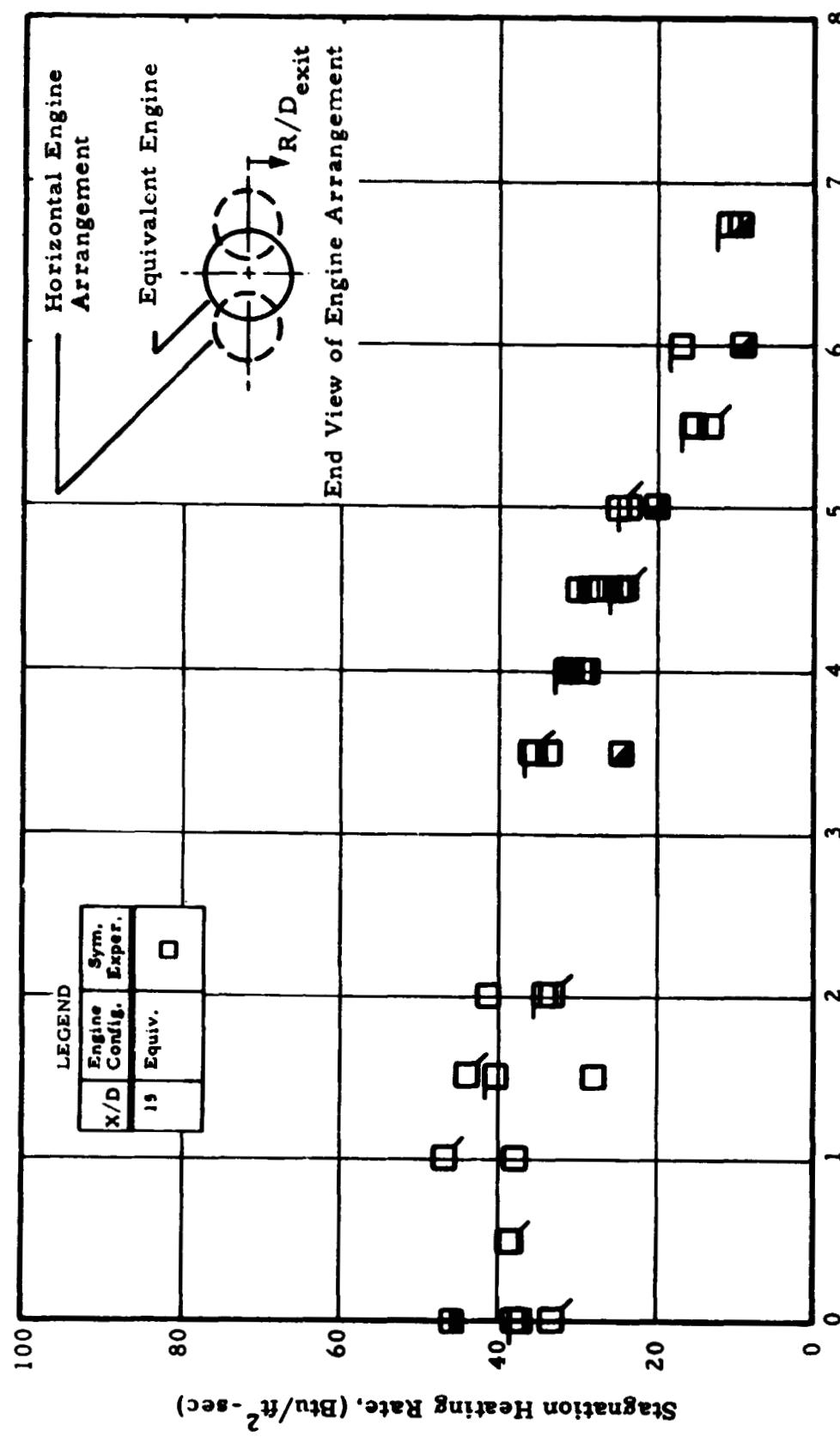


Fig. 32 - Radial Distribution of the Plume Stagnation Heating Rates in the Orbiter Main Engine Exhaust Plume at X/D = 15 from the Engine Exit Plane (Equivalent Engine)

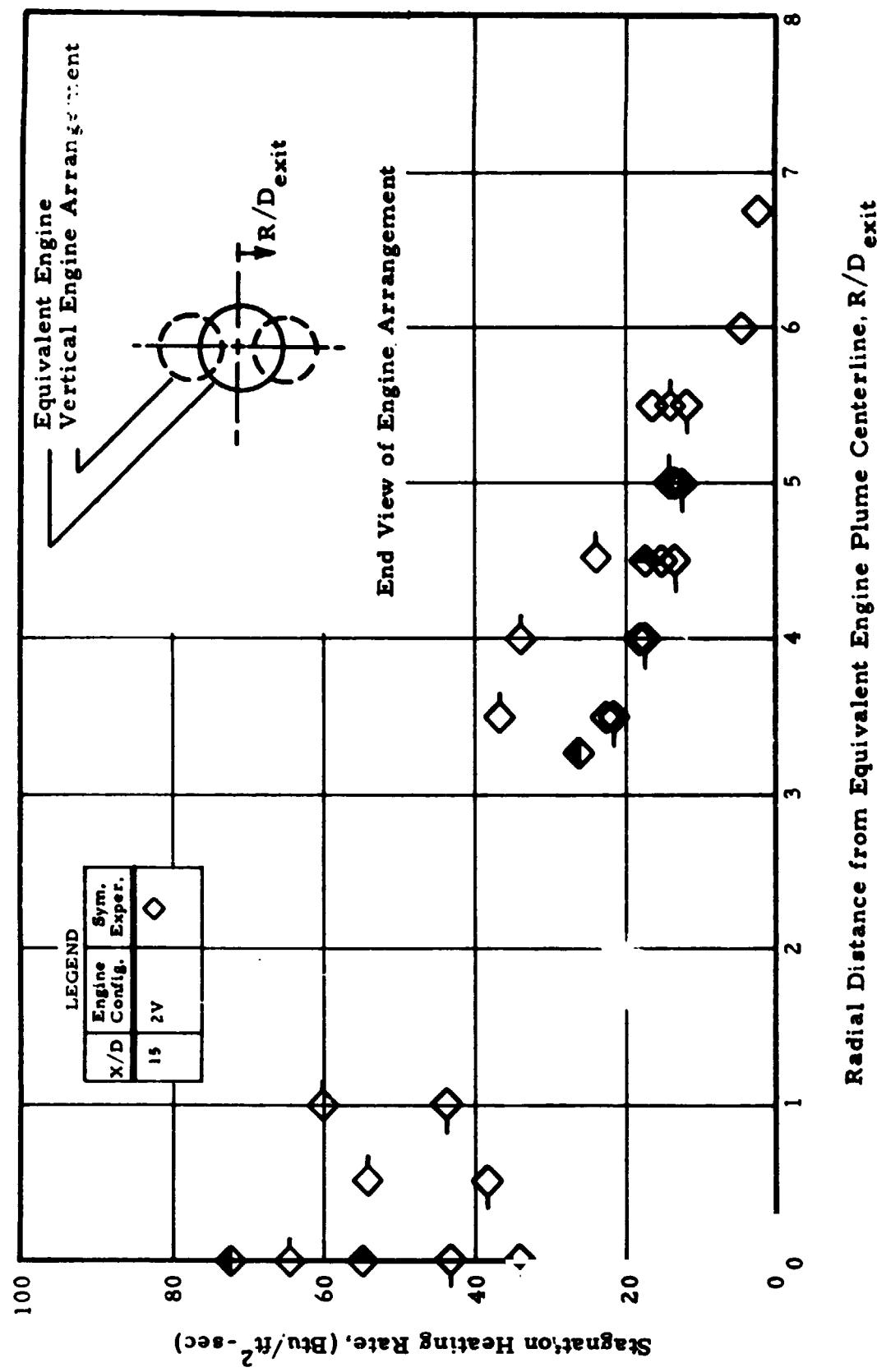


Fig. 33 - Radial Distribution of the Plume Stagnation Heating Rates in the Orbiter Main Engine Exhaust Plume at $X/D = 15$ from the Engine Exit Plane (Vertical Engine Arrangement)

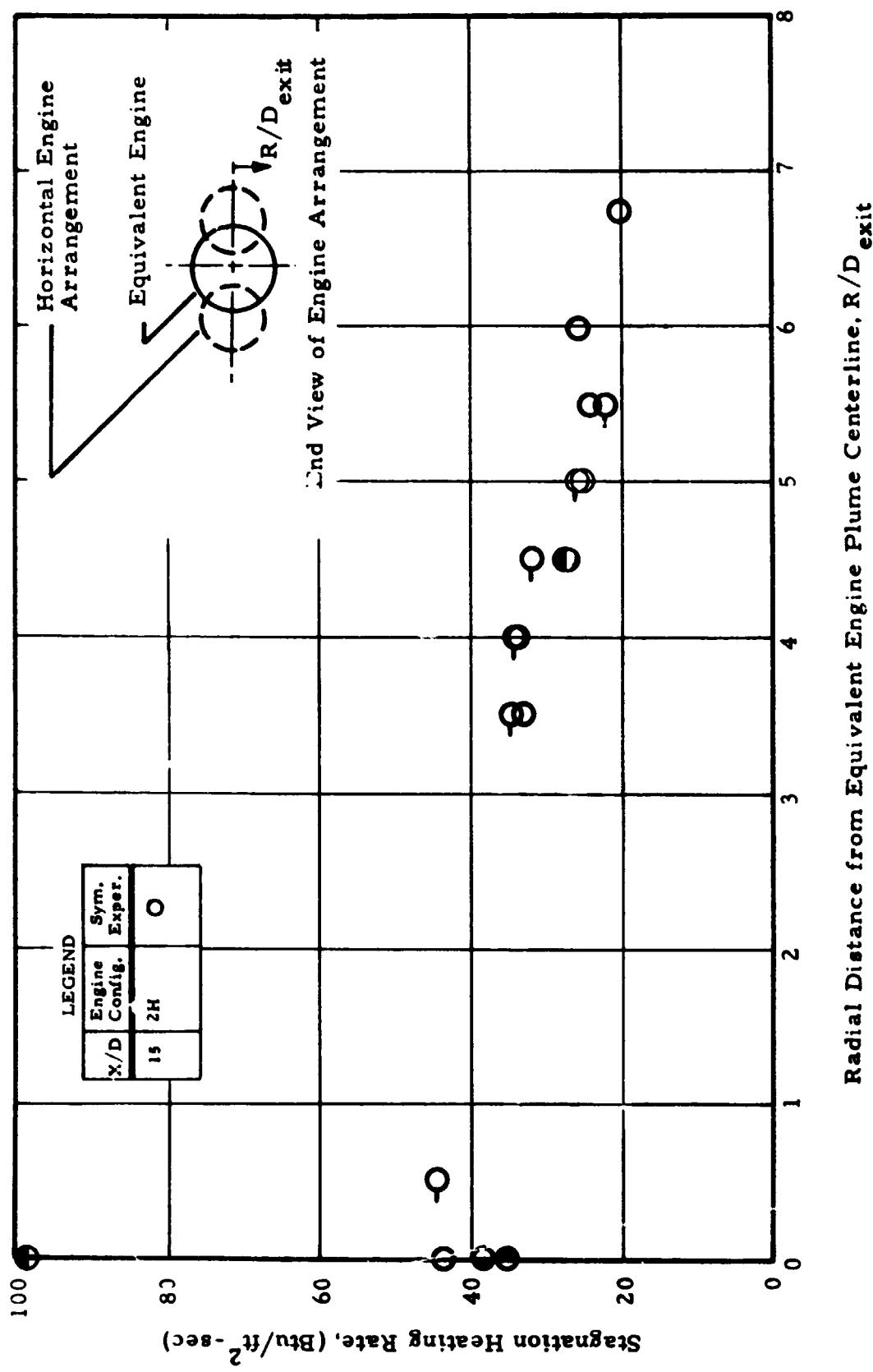


Fig. 34 - Radial Distribution of the Plume Stagnation Heating Rates in the Orbiter Main Engine Exhaust Plume at X/D = 15 from the Engine Exit Plane (Horizontal Engine Arrangement)

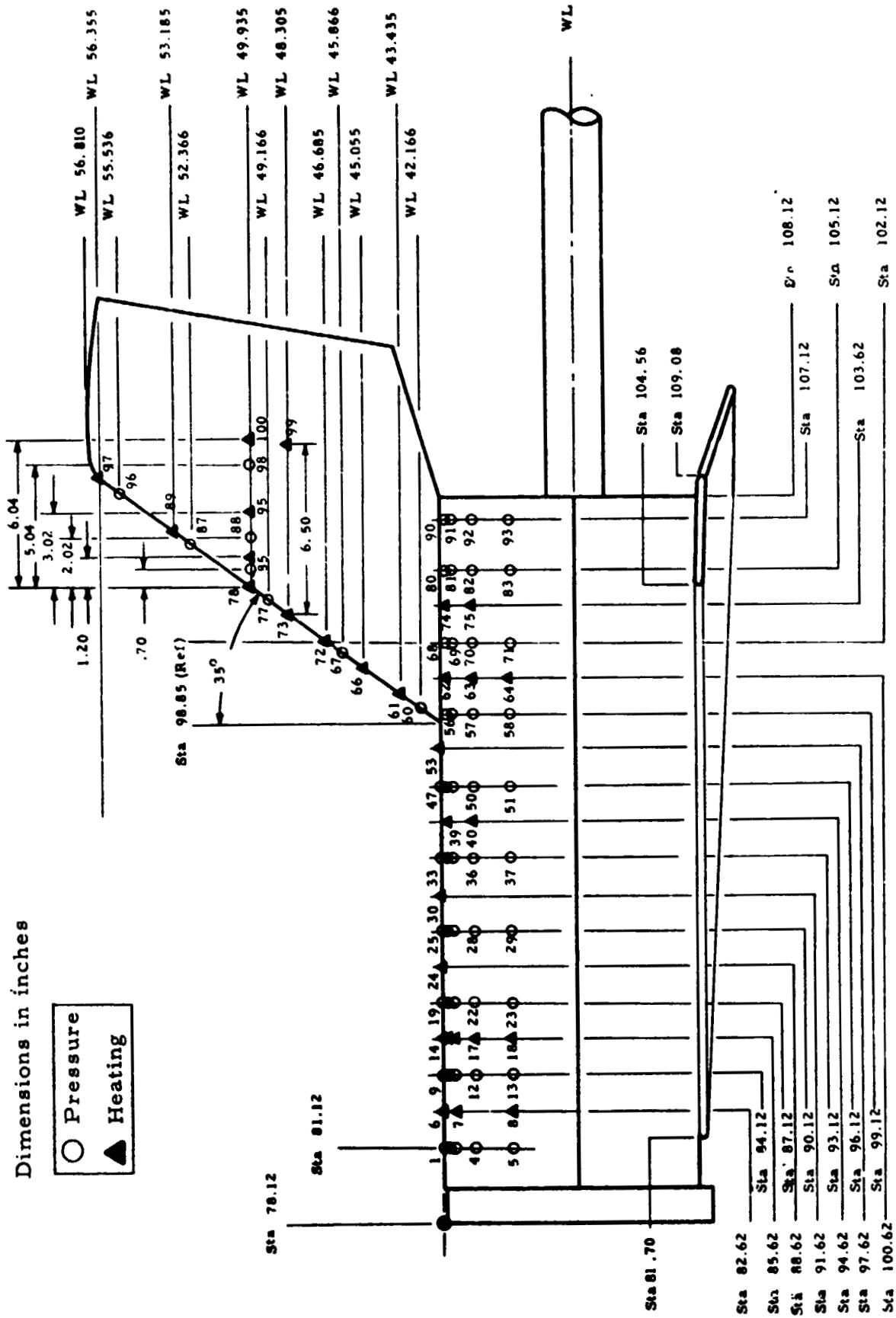


Fig. 35 - Model Instrumentation Locations - Side View

Dimensions in inches

○ Pressure	▲ Heating
------------	-----------

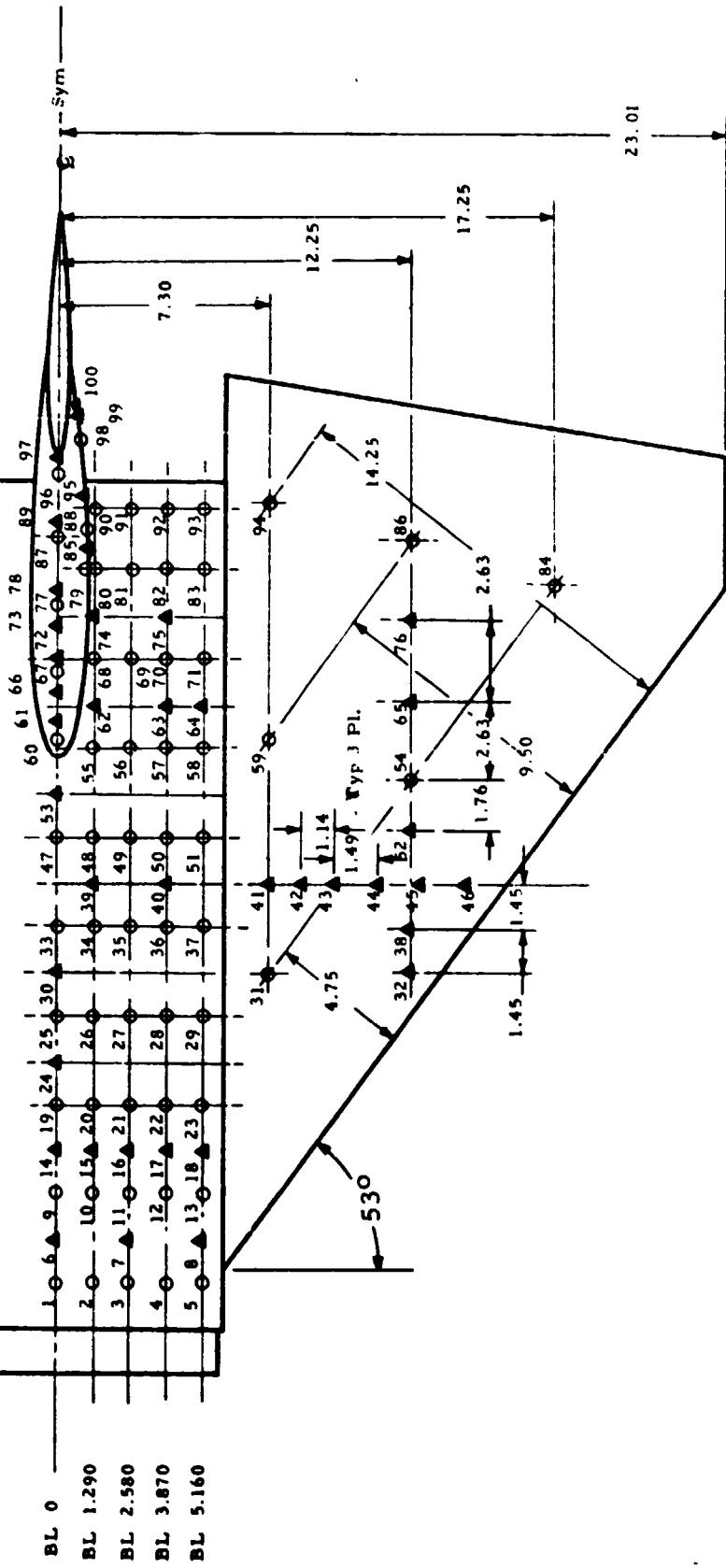


Fig. 36 - Model Instrumentation Locations - Top View

LMSC-HREC D225839

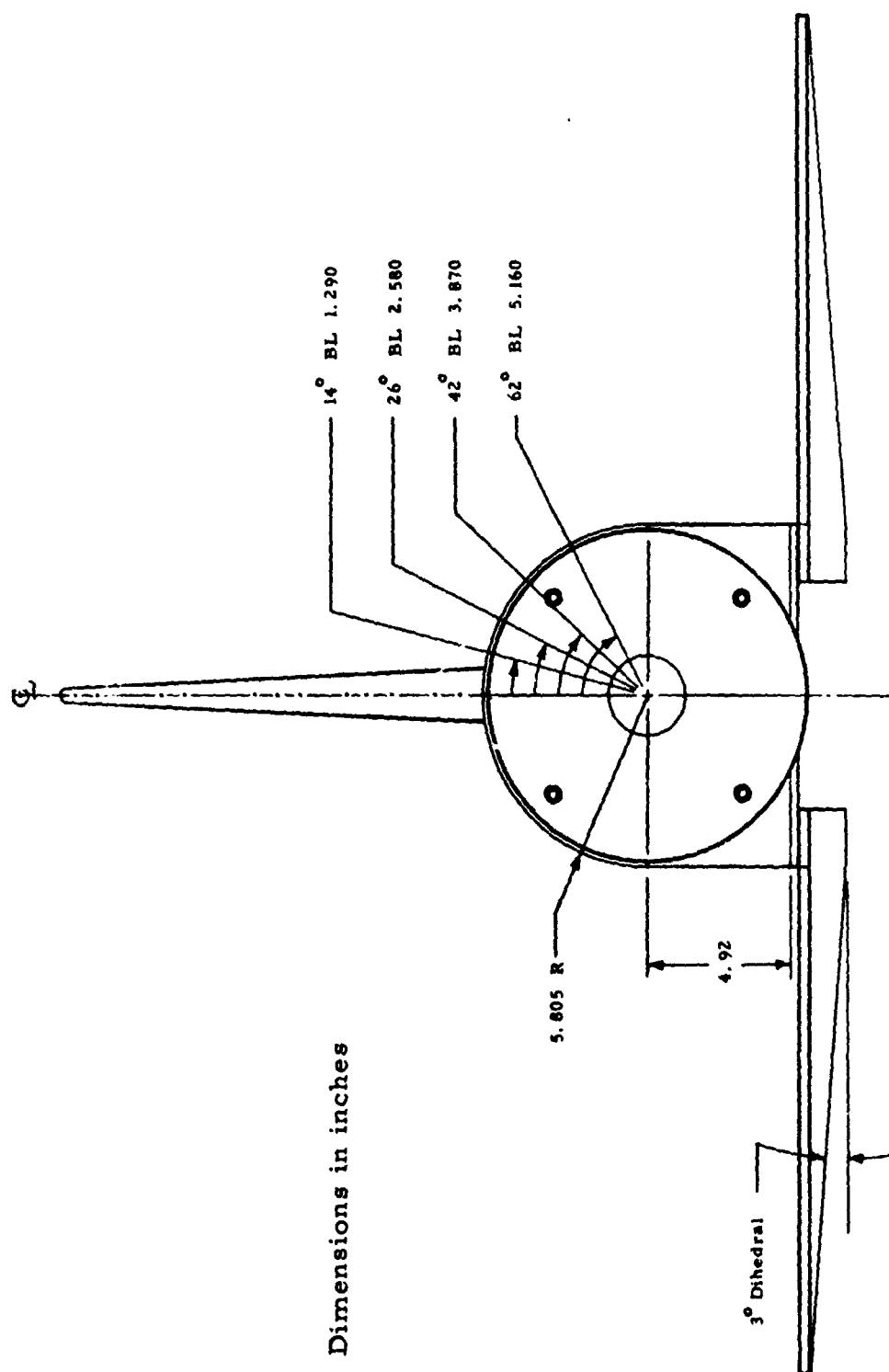


Fig. 37 - Model Instrumentation Locations - Front View

LMSC-HREC D225839

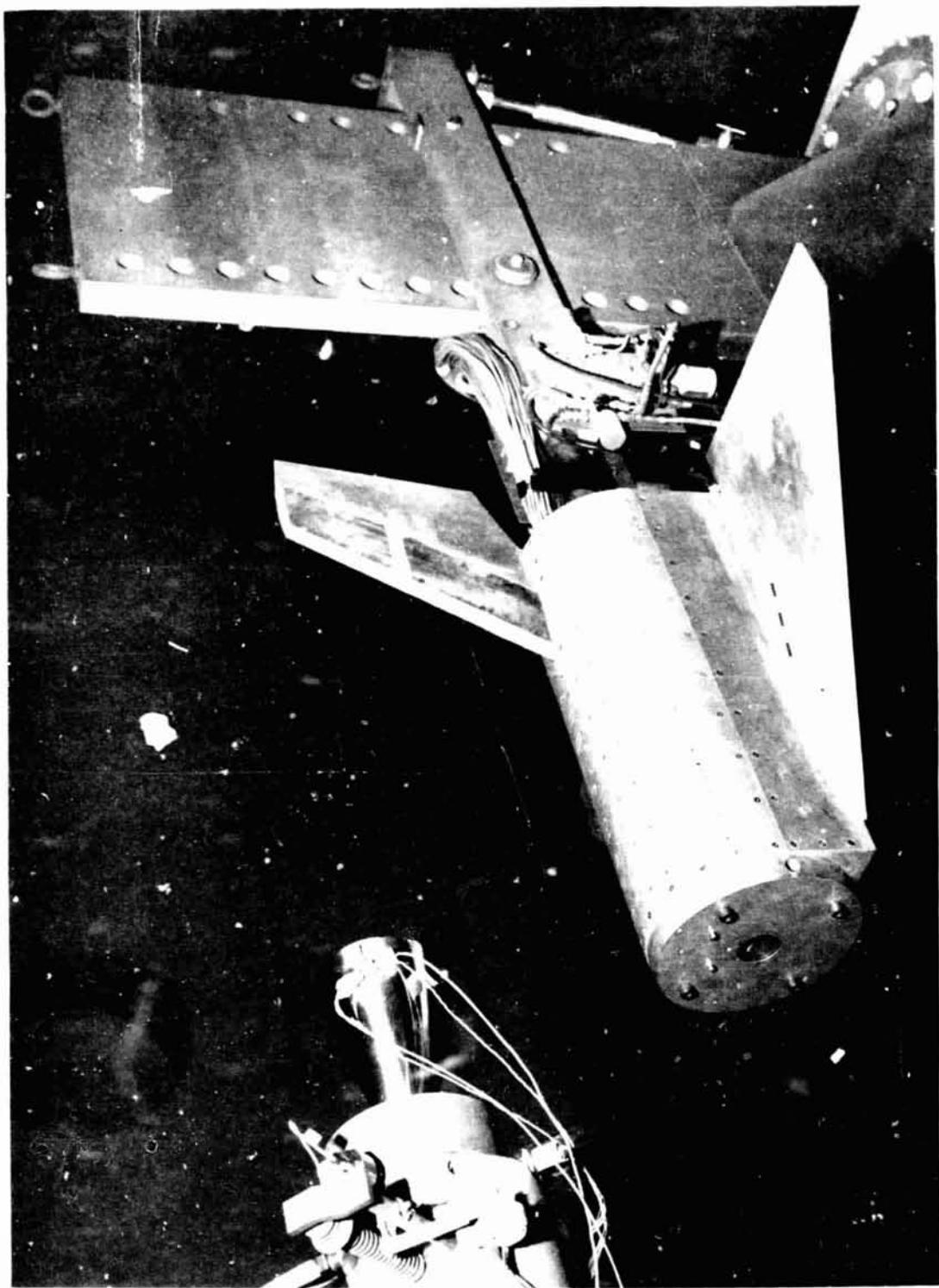


Fig. 38 - Model and Equivalent Engine Configuration

PRECEDING PAGE BLANK NOT FILMED

LMSC-HREC D225839

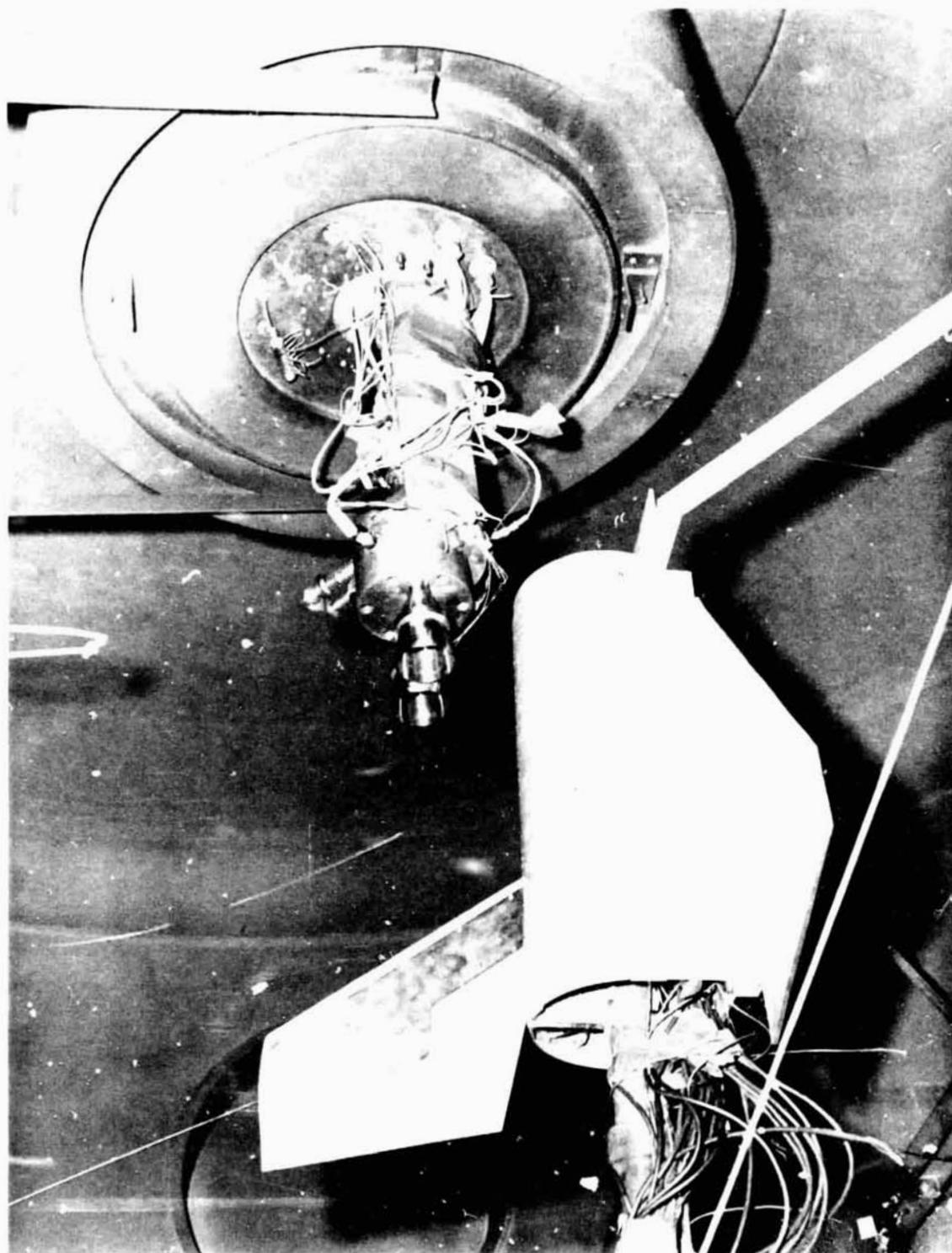


Fig. 39 - Model and Dual Horizontal Engine Configuration

LMSC-HREC D225839

PRECEDING PAGE BLANK NOT FILMED

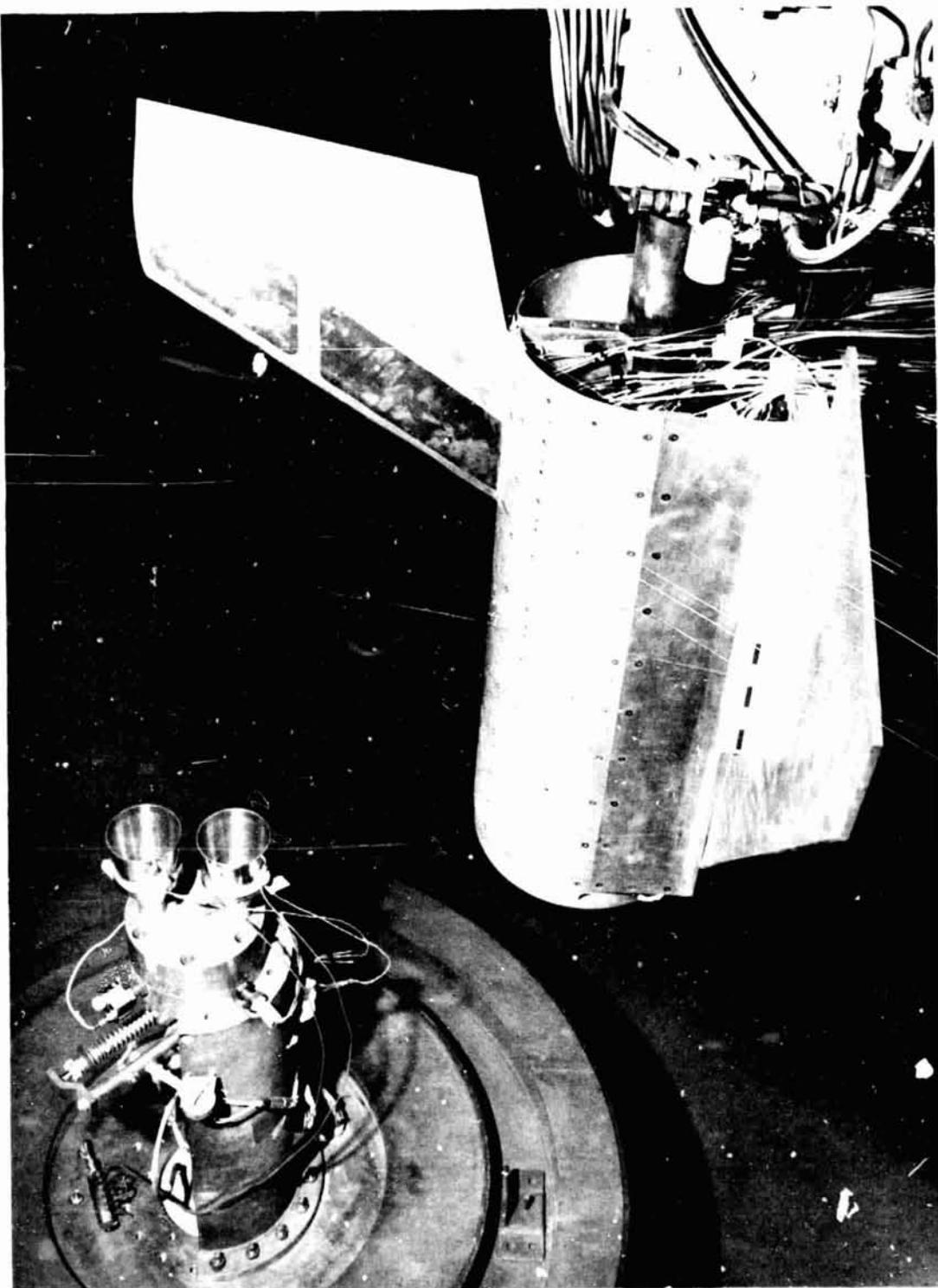
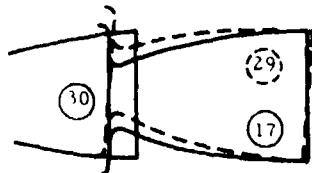


Fig. 40 - Model and Dual Vertical Engine Configuration

NOTE: α = inclination of orbiter engine centerline with respect to the booster fuselage centerline

D_{equiv} = exit diameter of the equivalent engine, 5.286 in.



Test Pos.	x (in.)	y (in.)	$\frac{x}{D_{equiv}}$	$\frac{y}{D_{equiv}}$	α (deg)
2	-3.297	4.644	-0.624	.878	0
4	-18.390	6.966	-3.479	1.318	0
5	-6.780	6.966	-1.283	1.318	0
8	-6.780	6.966	-1.283	1.318	5
11	-11.424	14.513	-2.161	2.746	4
14	-11.424	14.513	-2.161	2.746	0
15	0.186	14.513	0.035	2.746	0
17	-6.780	23.22	-1.283	4.393	0
29	-6.780	23.22	-1.283	4.393	5
30	-1.180	23.22	-0.223	4.393	0
31	-8.424	14.513	-1.594	2.746	0

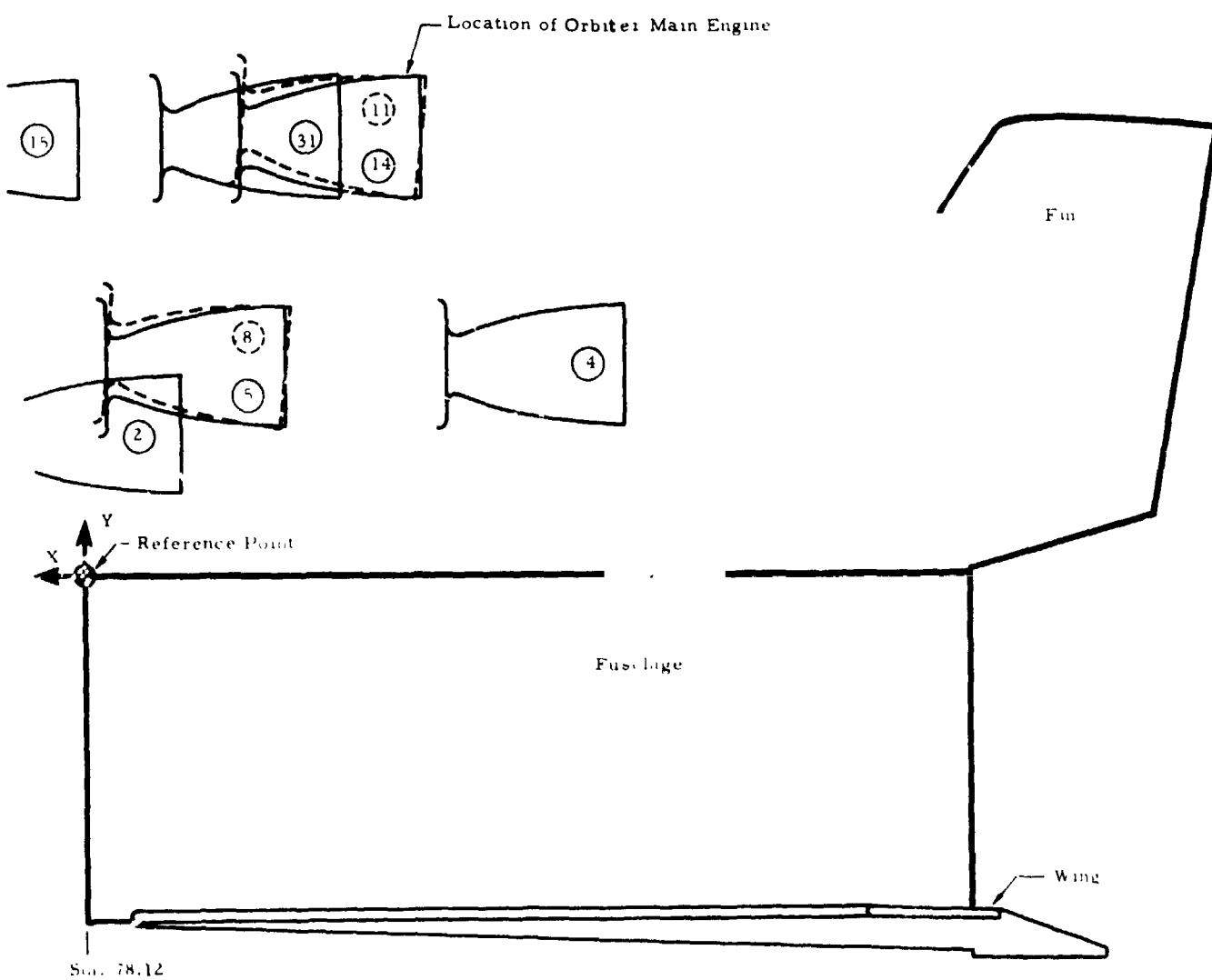


Fig. 41 - Engine/Booster Relative Test Positions

NOTE: All dimensions in inches

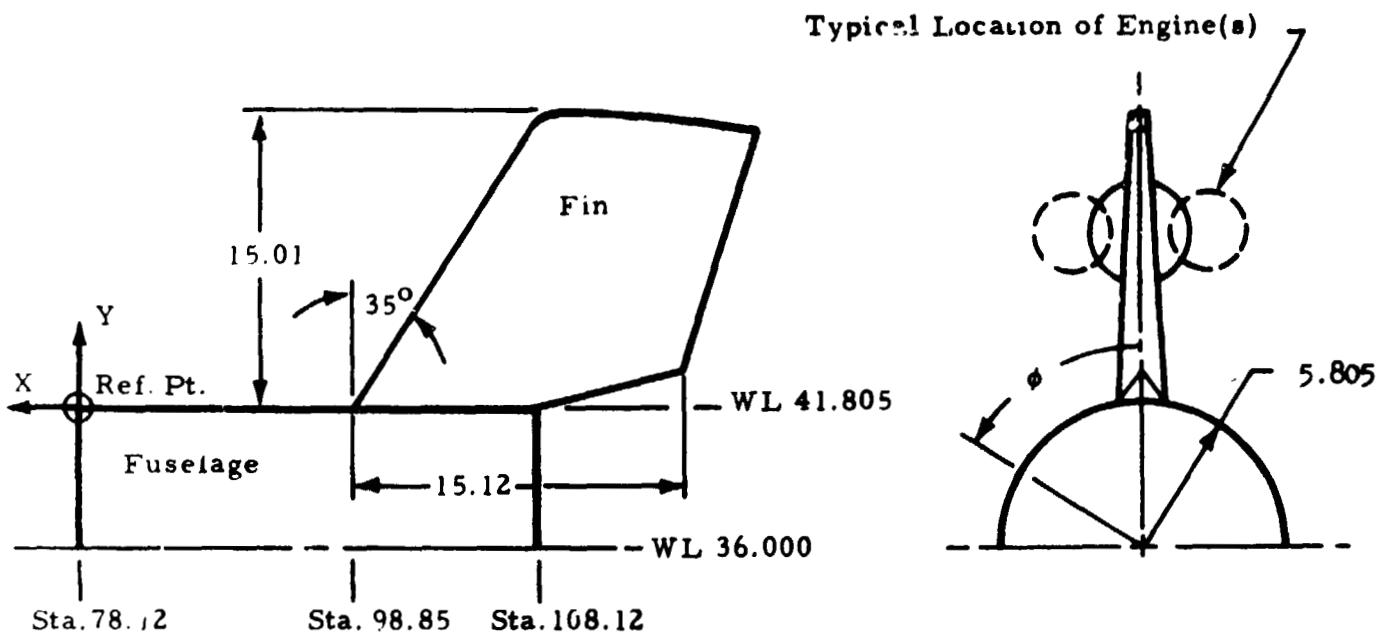
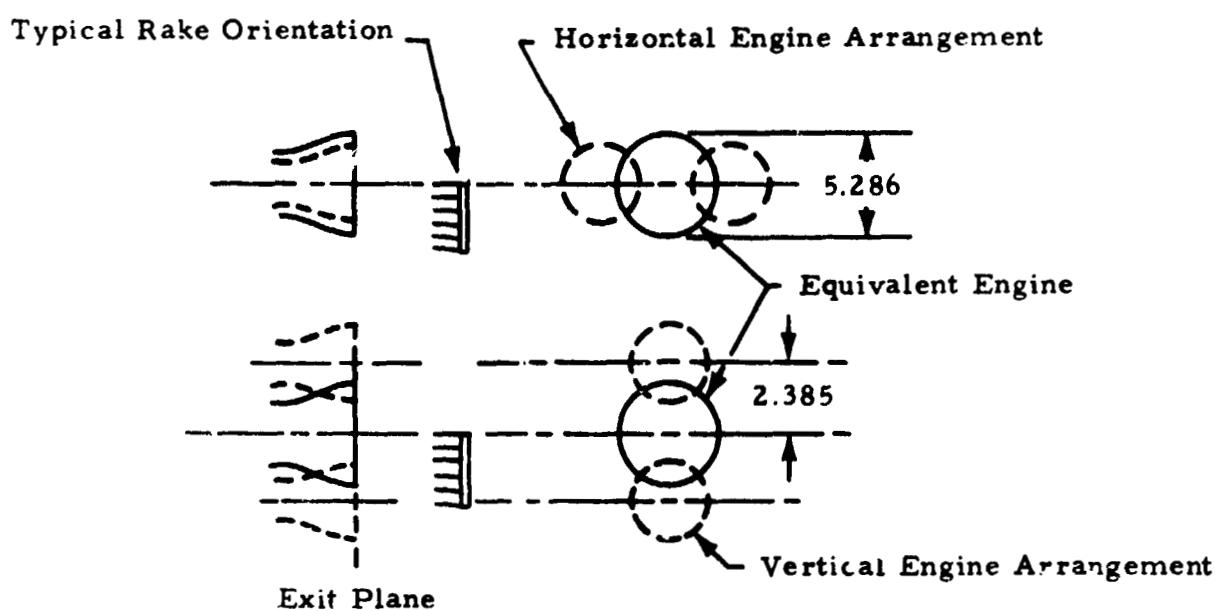
Sketch of Booster GeometrySketch of Engine Arrangement

Fig. 42 - Sketch of Model Geometry and Engine Arrangement

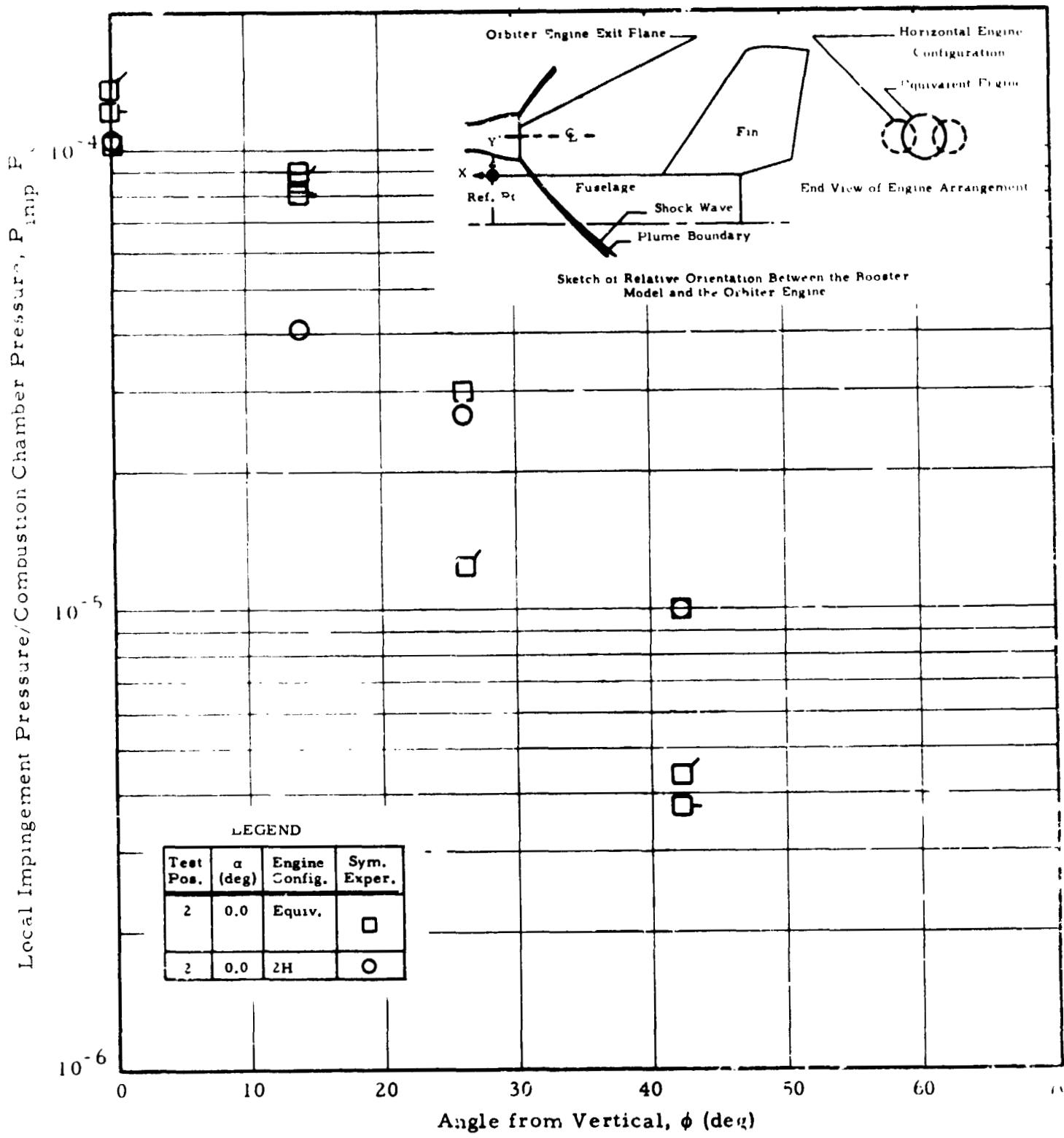


Fig. 43 - Impingement Pressure Distribution over the Booster Fuselage at Station 87.12 (Test Pos. 2)

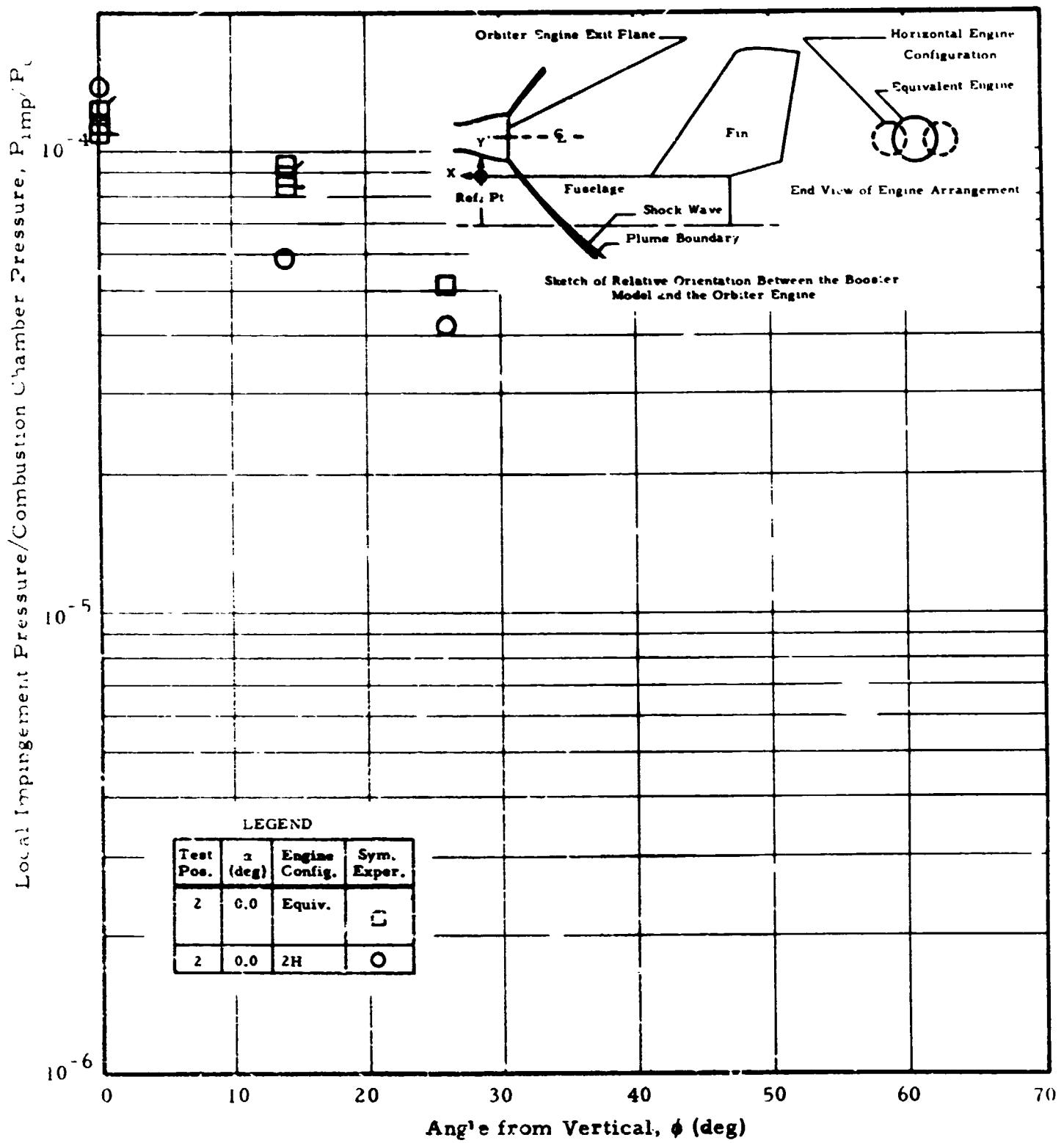


Fig. 44 - Impingement Pressure Distribution over the Booster Fuselage at Station 90.12 (Test Pos. 2)

LMSC-HREC D225839

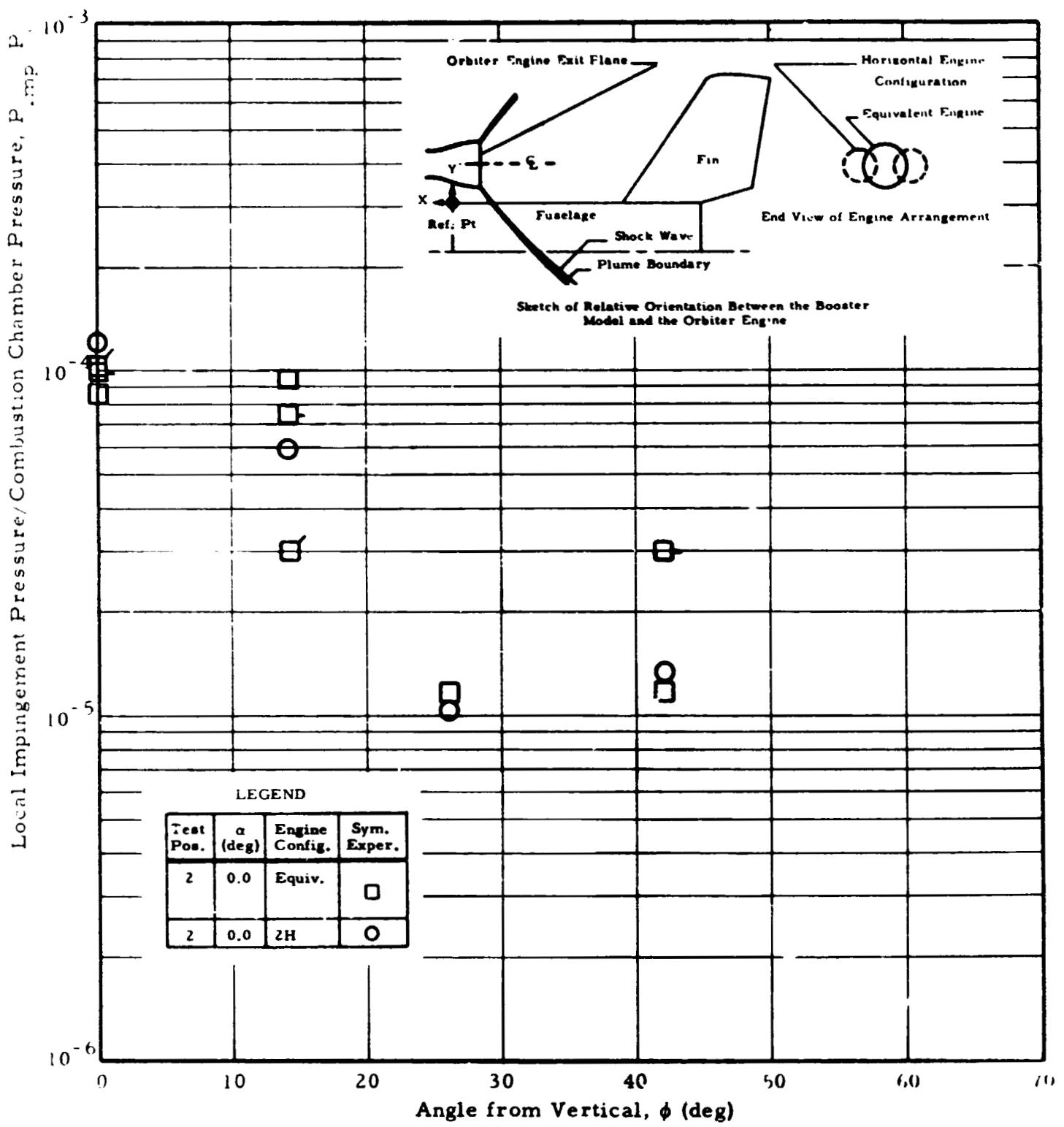


Fig. 45 - Impingement Pressure Distribution over the Booster Fuselage at Station 93.12 (Test Pos. 2)

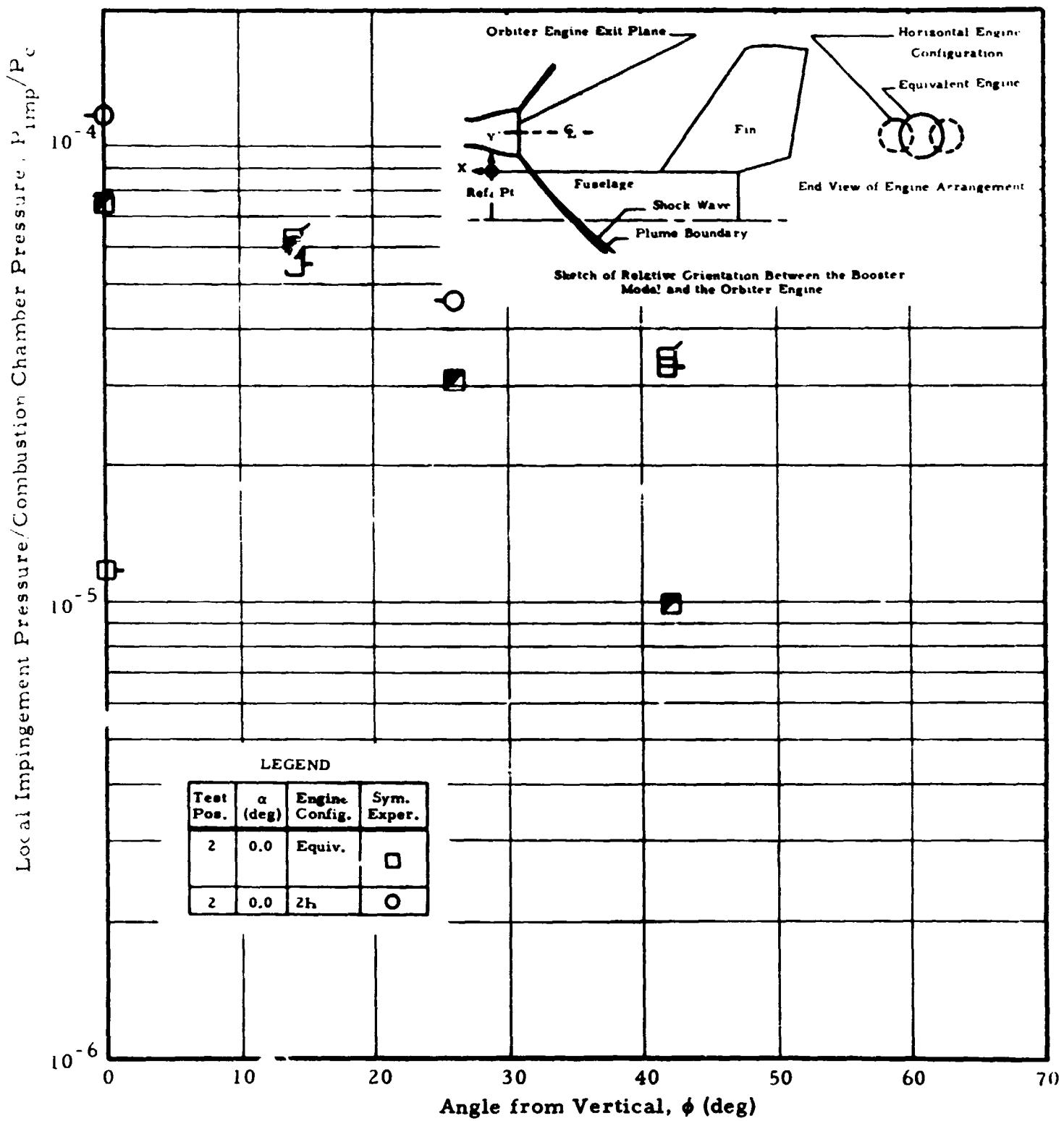


Fig. 46 Impingement Pressure Distribution over the Booster Fuselage at Station 96.12 (Test Pos. 2)

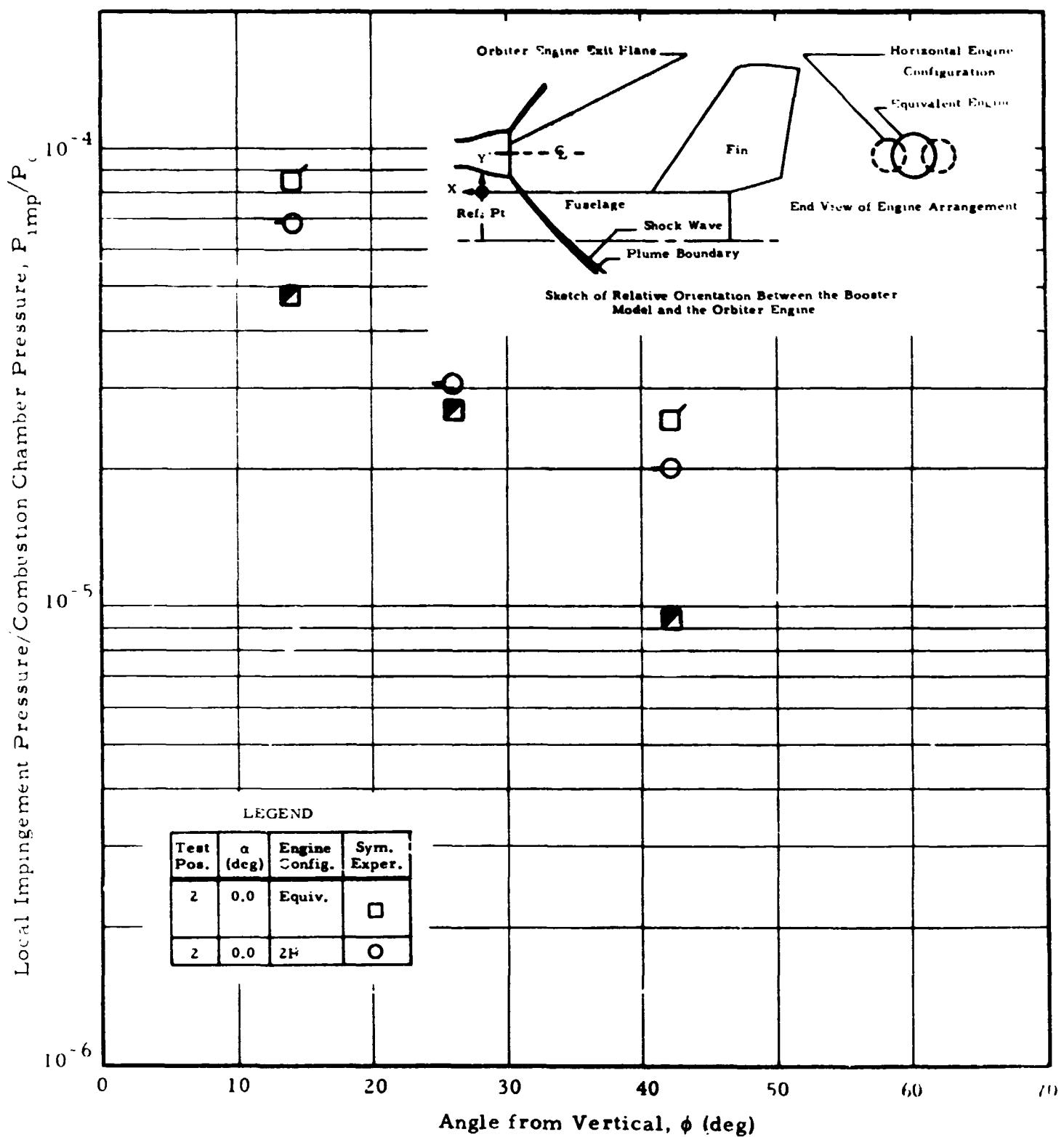


Fig. 47 - Impingement Pressure Distribution over the Booster Fuselage at Station 99.12 (Test Pos. 2)

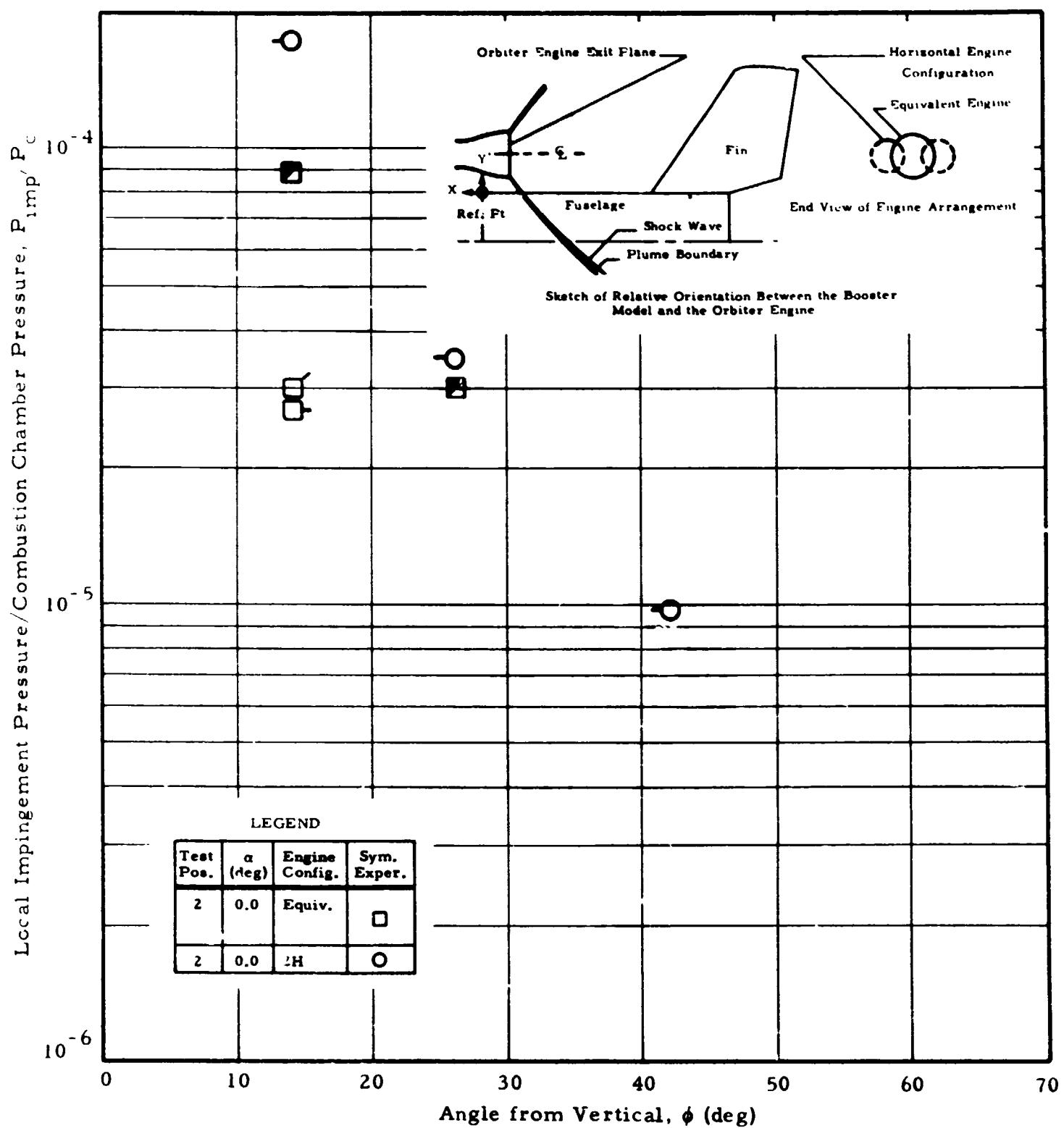


Fig. 48 - Impingement Pressure Distribution over the Booster Fuselage
at Station 102.12 (Test Pos. 2)

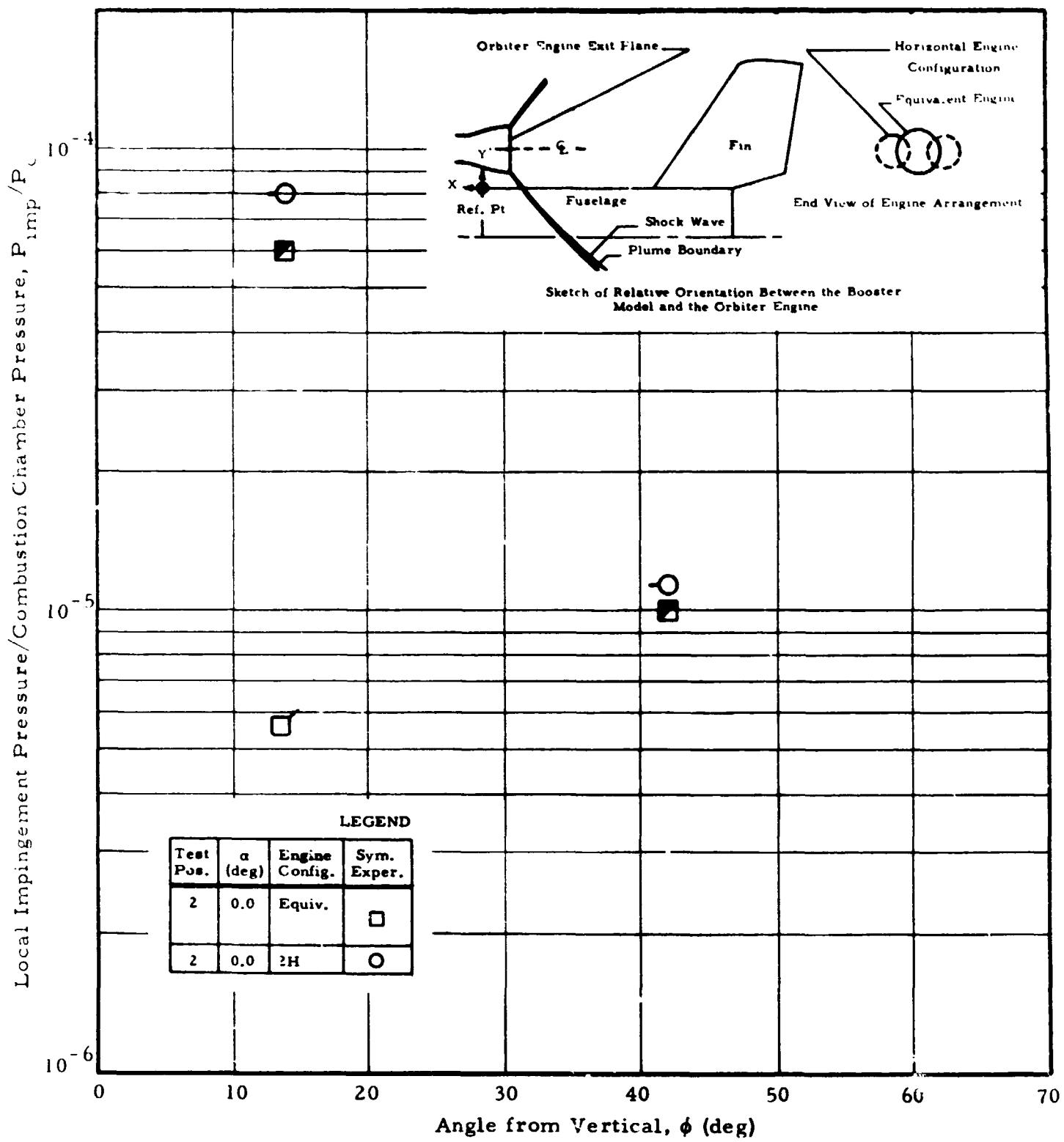


Fig. 49 - Impingement Pressure Distribution over the Booster Fuselage at Station 105.12 (Test Pos. 2)

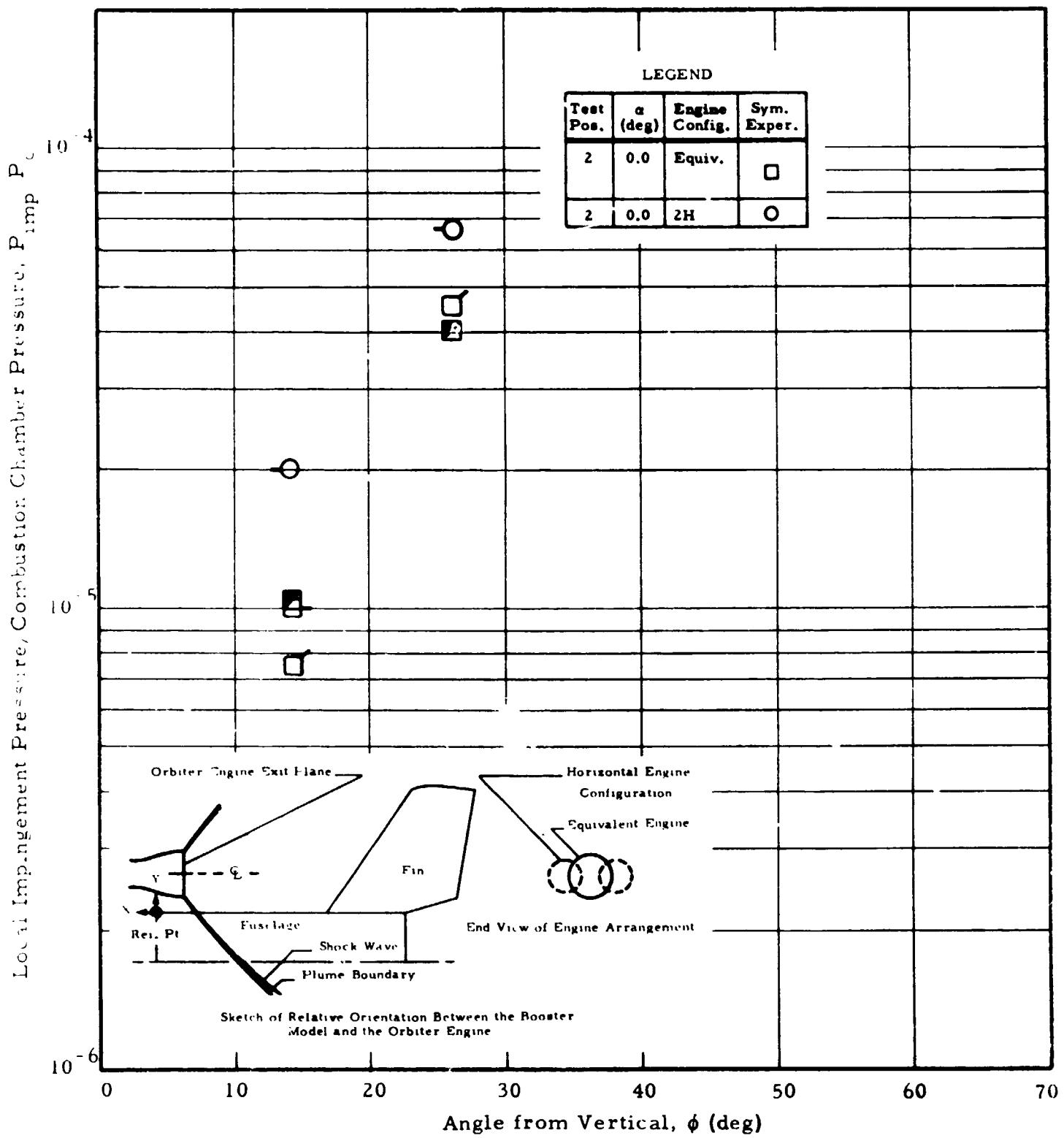


Fig. 50 - Impingement Pressure Distribution over the Booster Fuselage at Station 107.12 (Test Pos. 2)

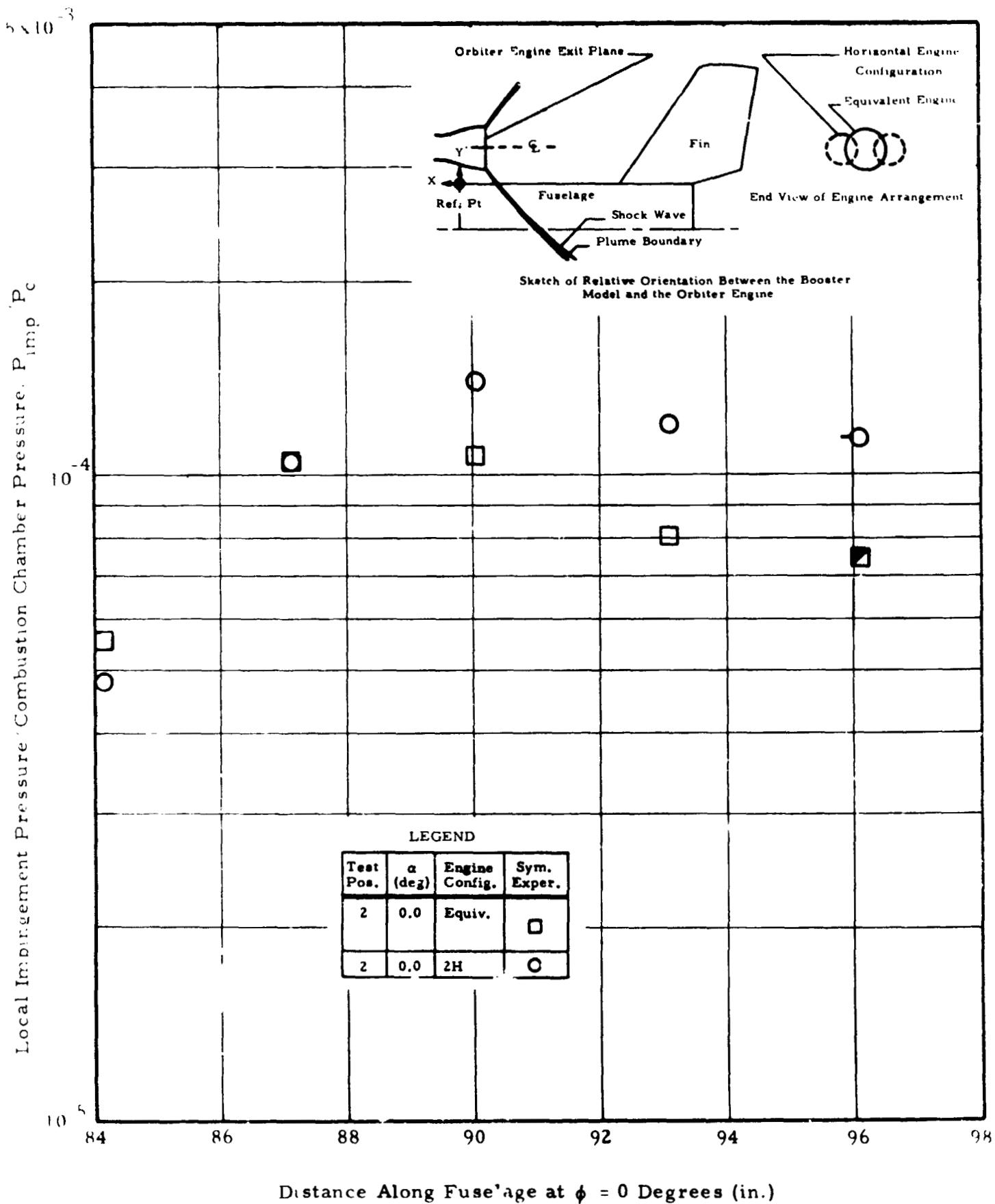


Fig. 51 - Impingement Pressure Distribution Along Fuselage Stagnation Line
(Test Pos. 2)

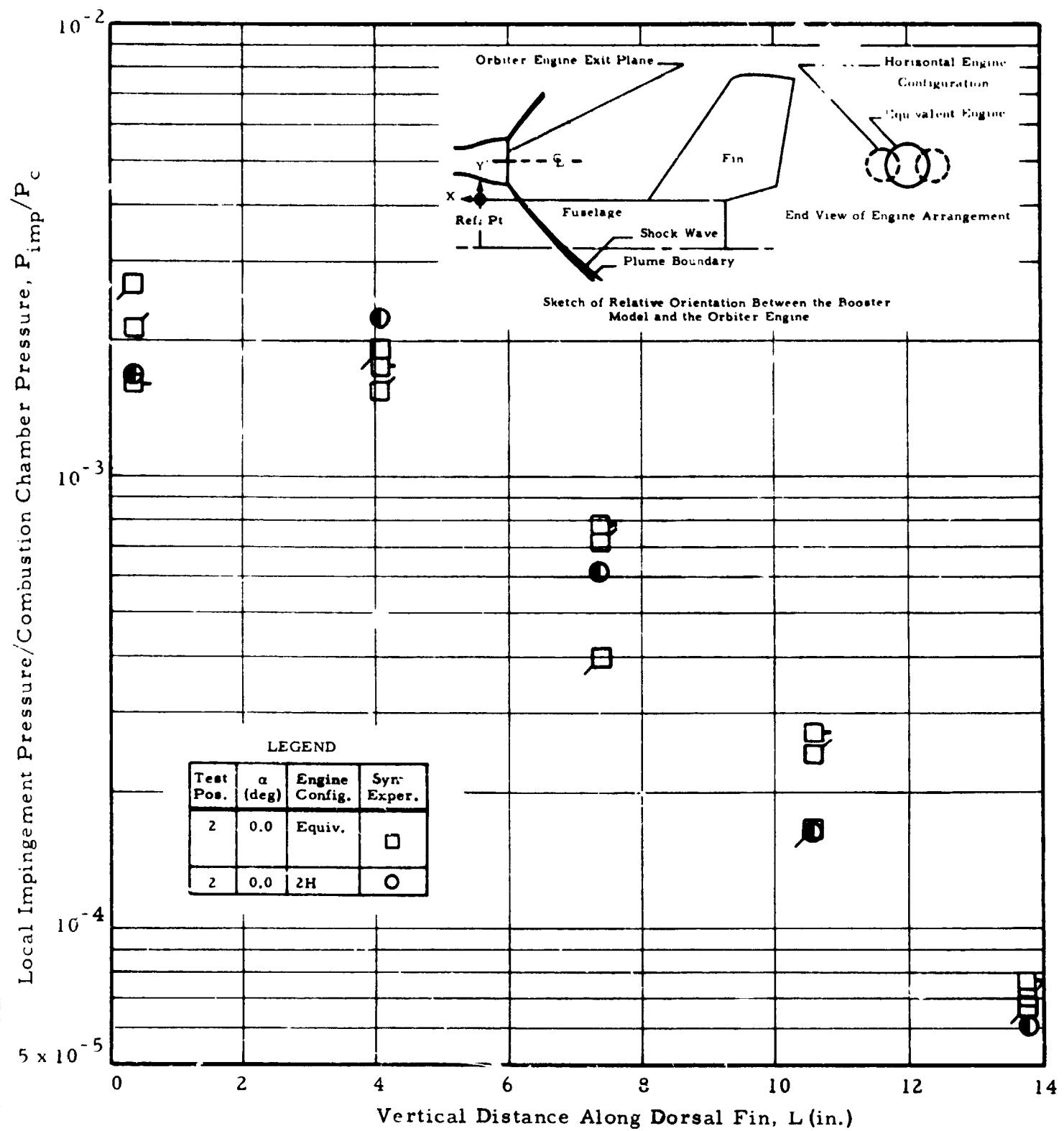


Fig. 52 - Impingement Pressure Distribution Along Dorsal Fin Leading Edge (Test Pos. 2)

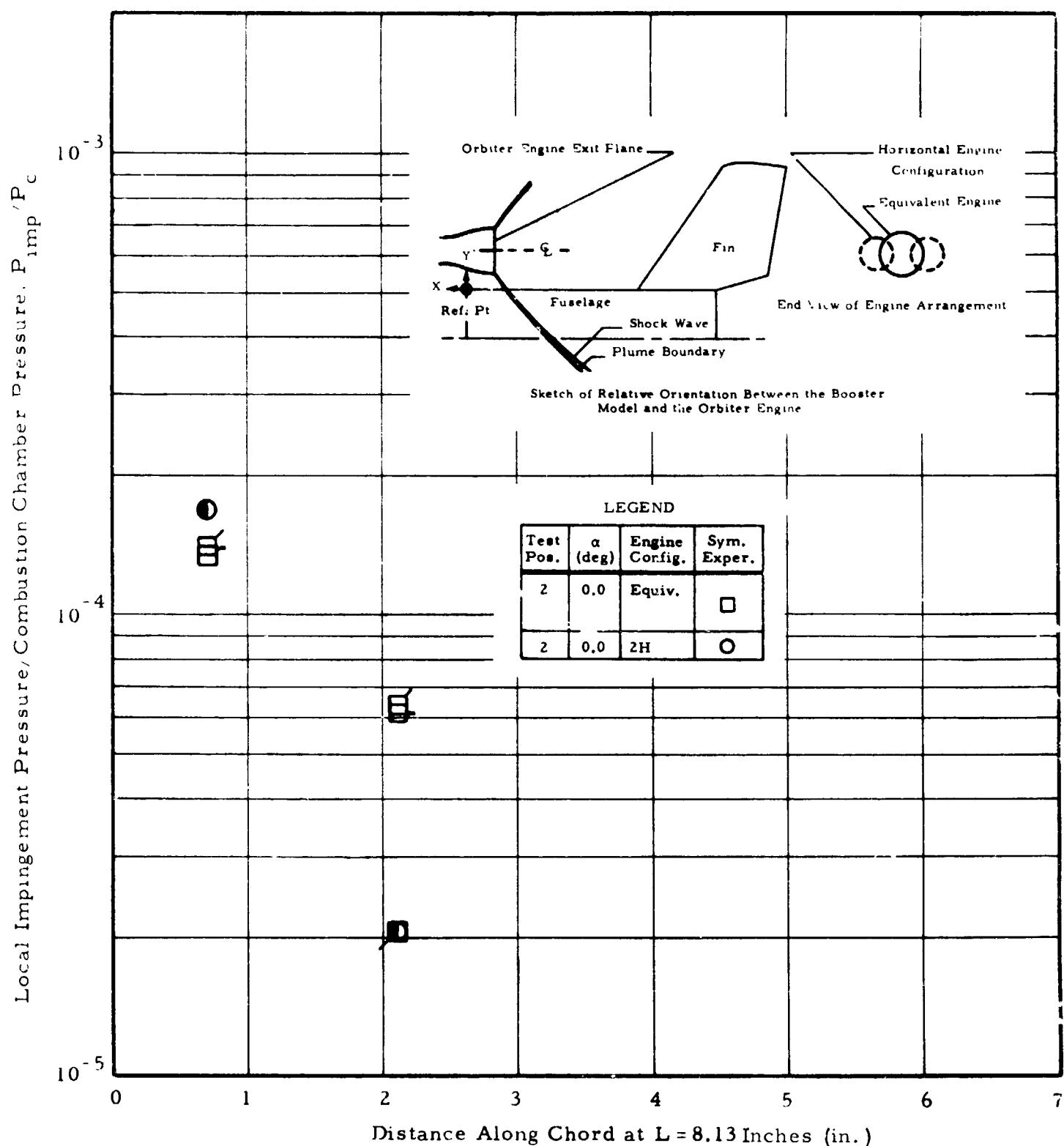


Fig. 53 - Impingement Pressure Distribution Along the Dorsal Fin Chord (Test Pos. 2)

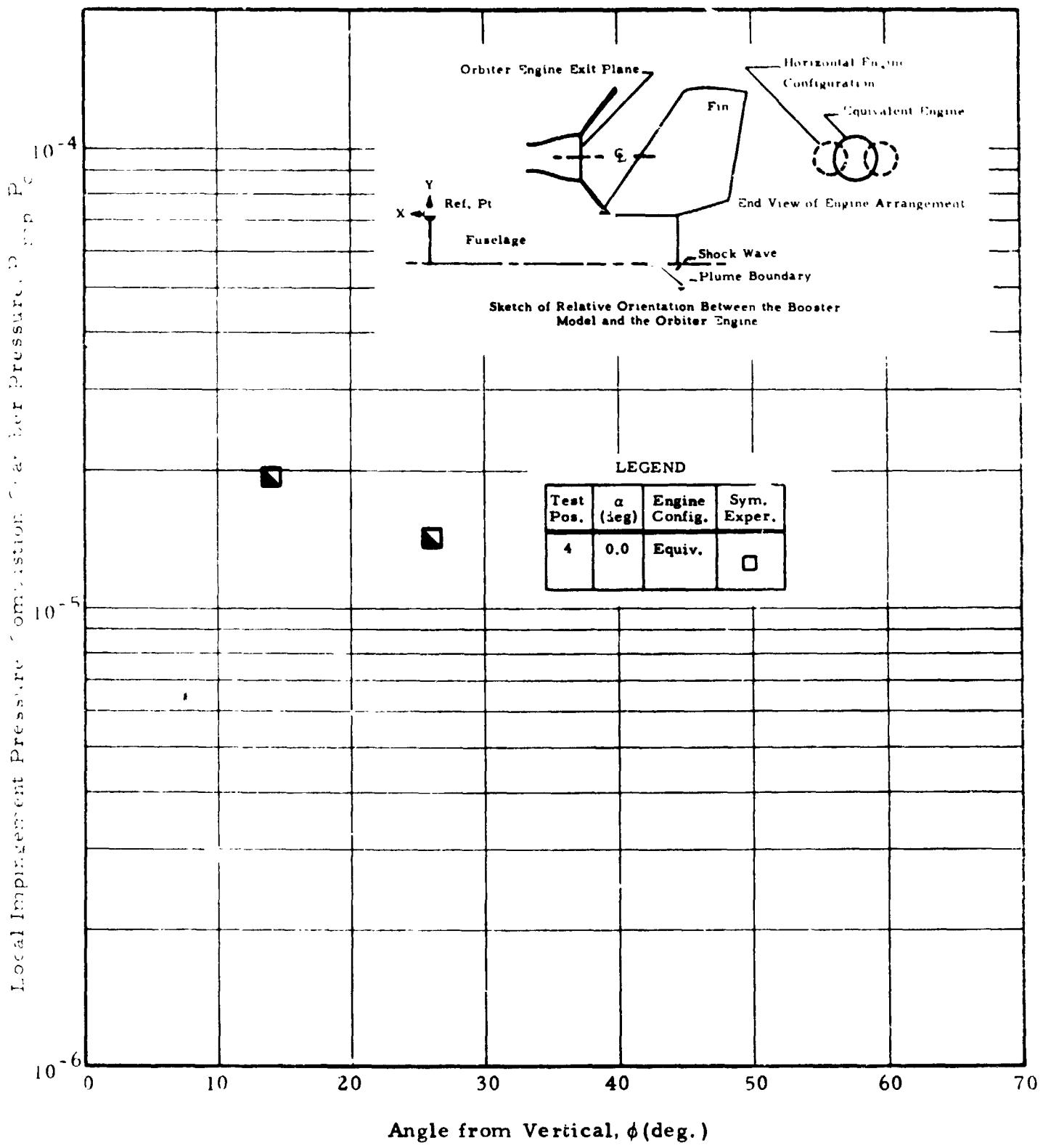


Fig. 54 - Impingement Pressure Distribution over the Booster Fuselage at Station 102.12 (Test Pos. 4)

LMSC-HREC D225839

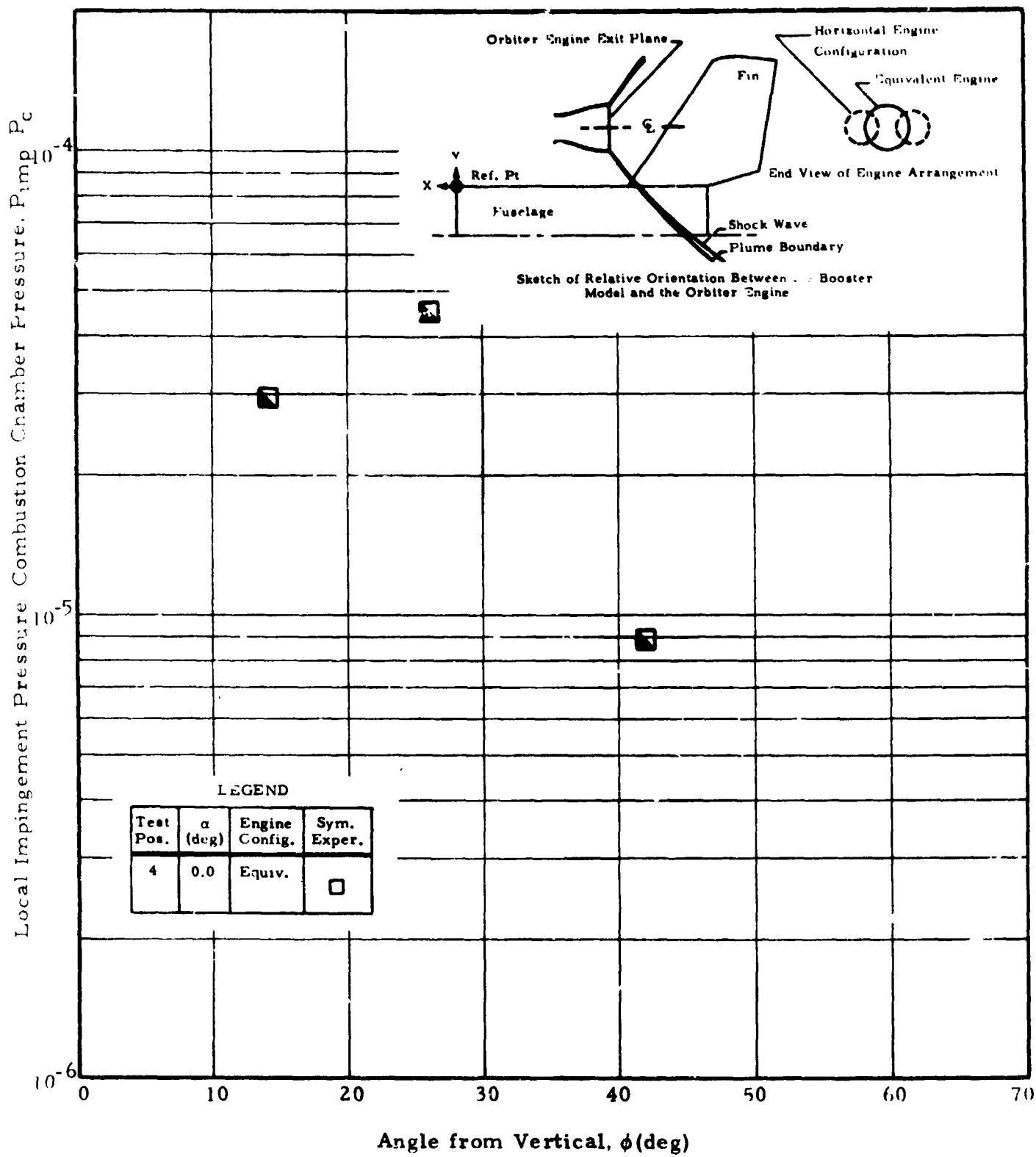


Fig. 55 - Impingement Pressure Distribution over the Booster Fusela Surface at Station 105.12 (Test Pos. 4)

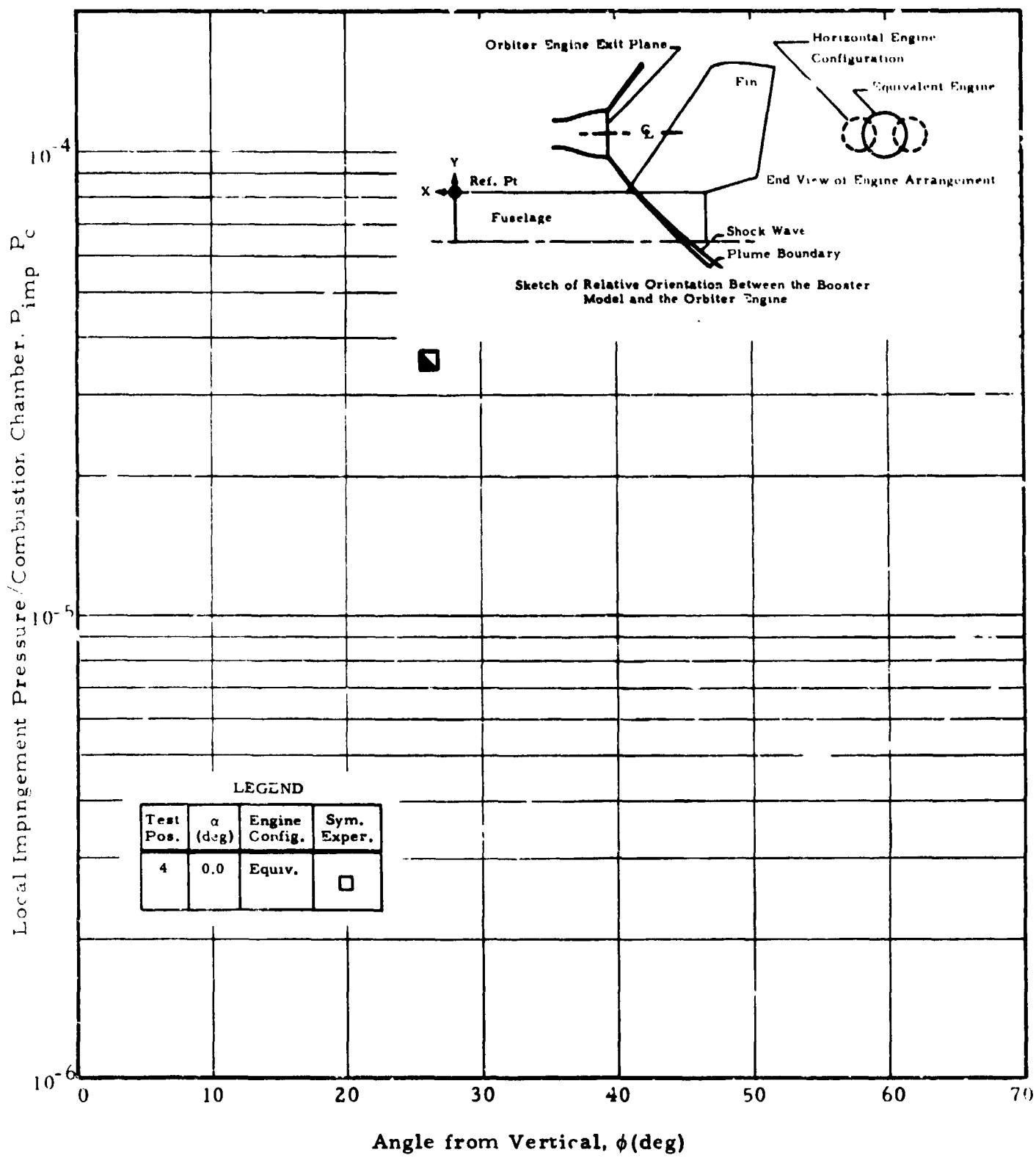


Fig. 56 - Impingement Pressure Distribution over the Booster Fuselage at Station 107.12 (Test Pos. 4)

LMSC-HREC D225839

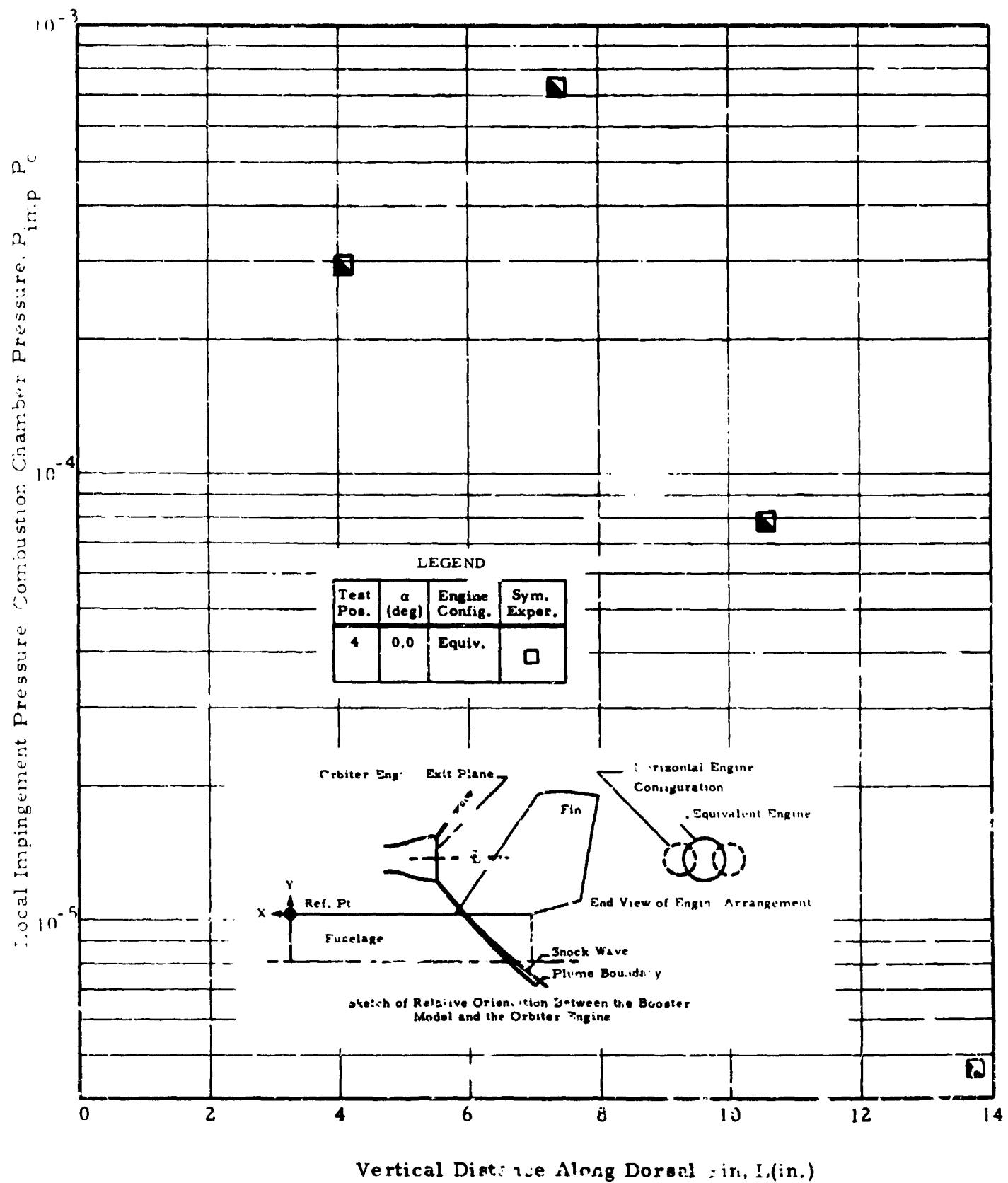


Fig. 57 - Impingement Pressure Distribution Along the Dorsal Fin
Leading Edge (Test Pos. 4)

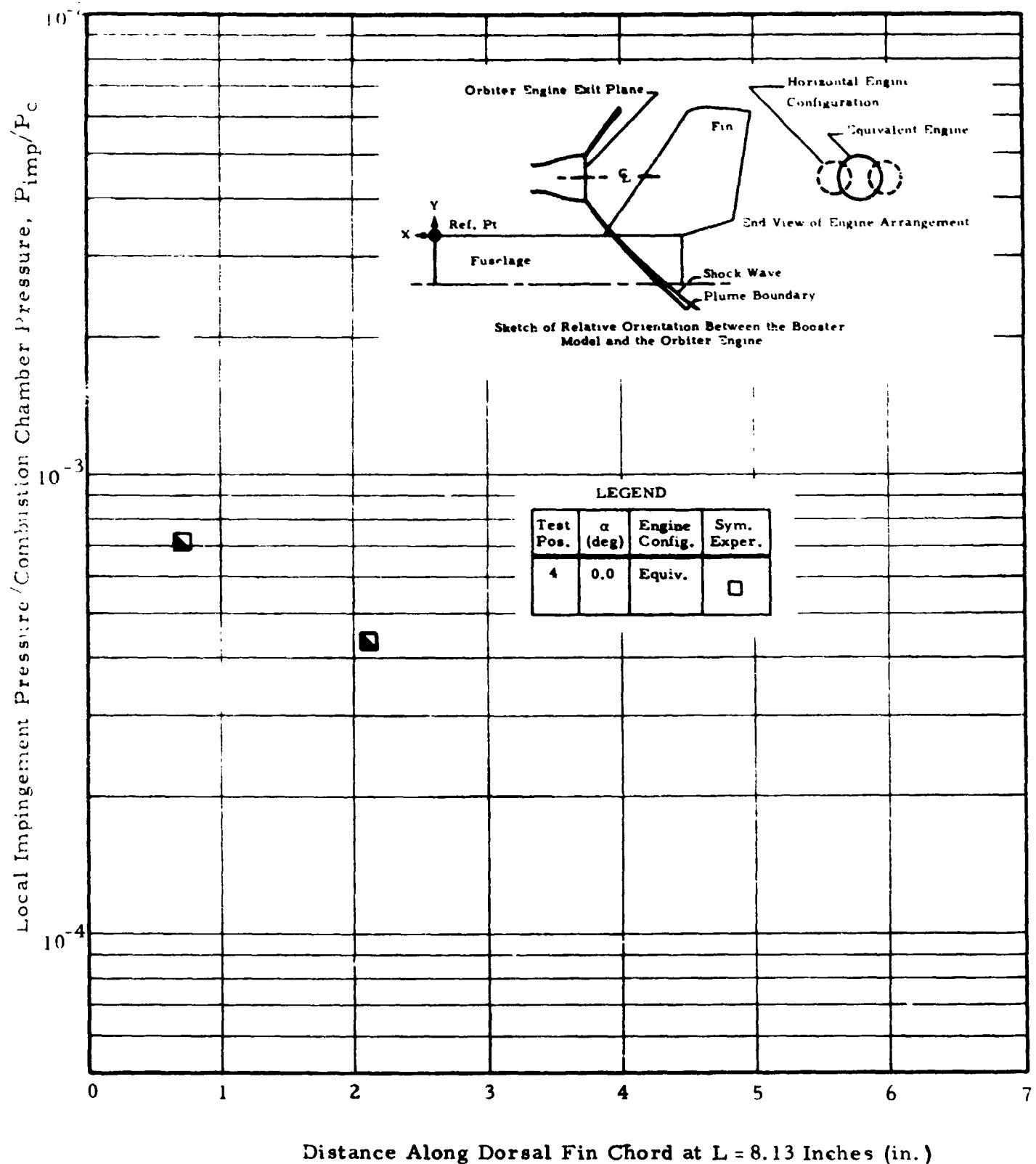


Fig. 58 - Impingement Pressure Distribution Along the Dorsal Fin Chord
(Test Pos. 4)

LMSC-HREC D225839

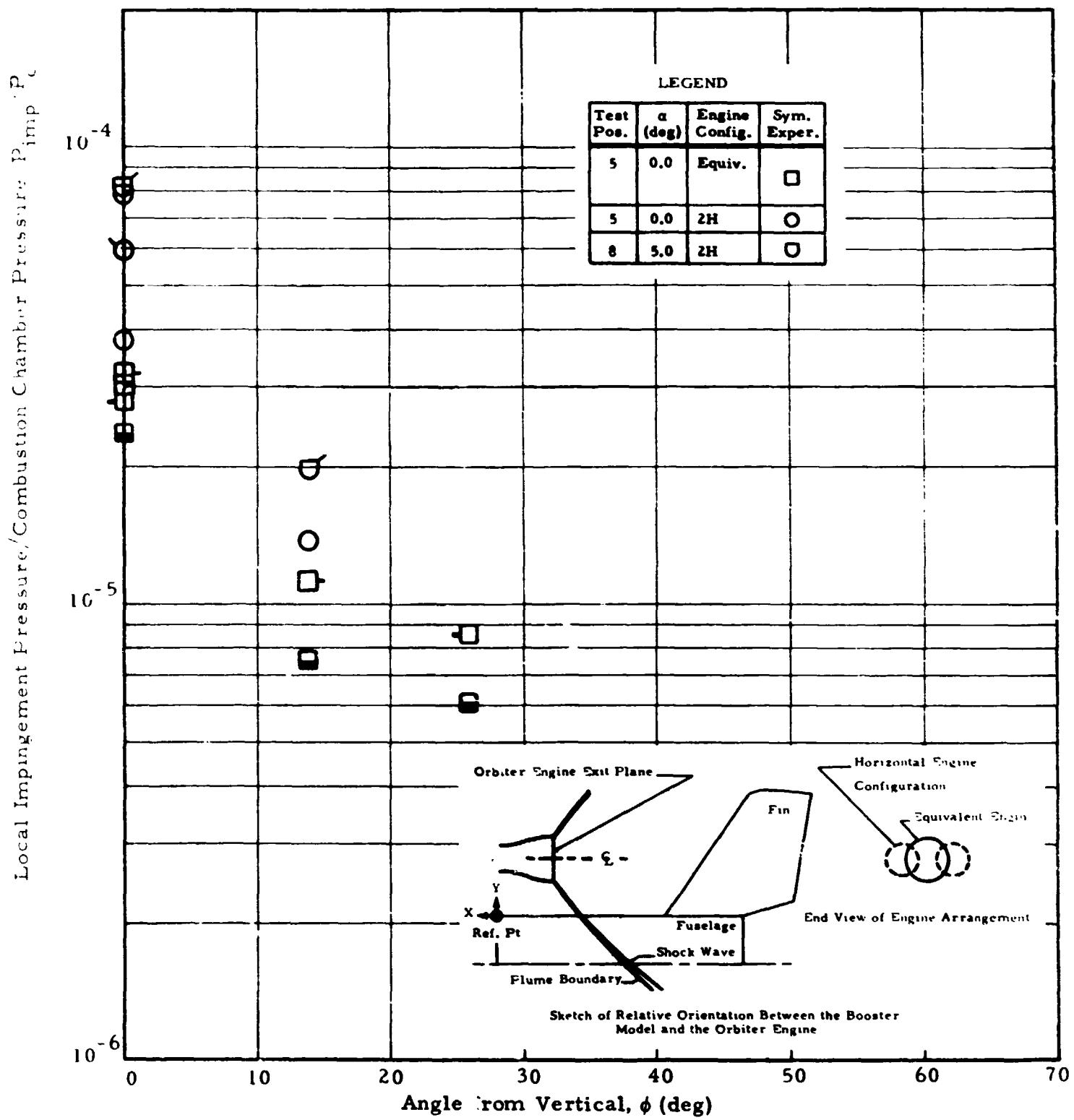


Fig. 59 - Impingement Pressure Distribution over the Booster Fuselage at Station 90.12 (Test Pos. 5 and Test Pos. 8)

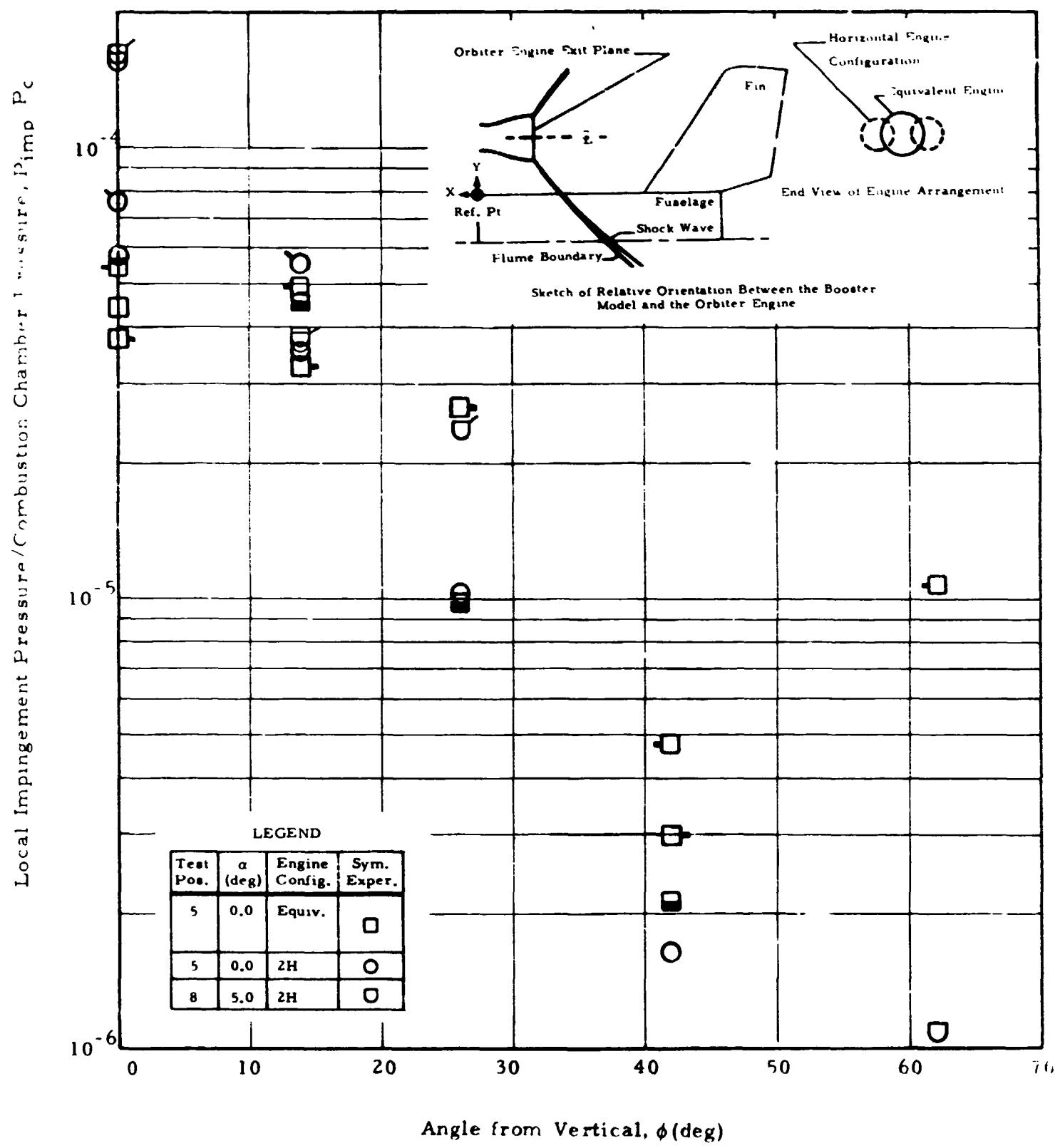


Fig. 60 - Impingement Pressure Distribution over the Booster Fuselage at Station 93.12 (Test Pos. 5 and Test Pos. 8)

LMSC-HREC D225938

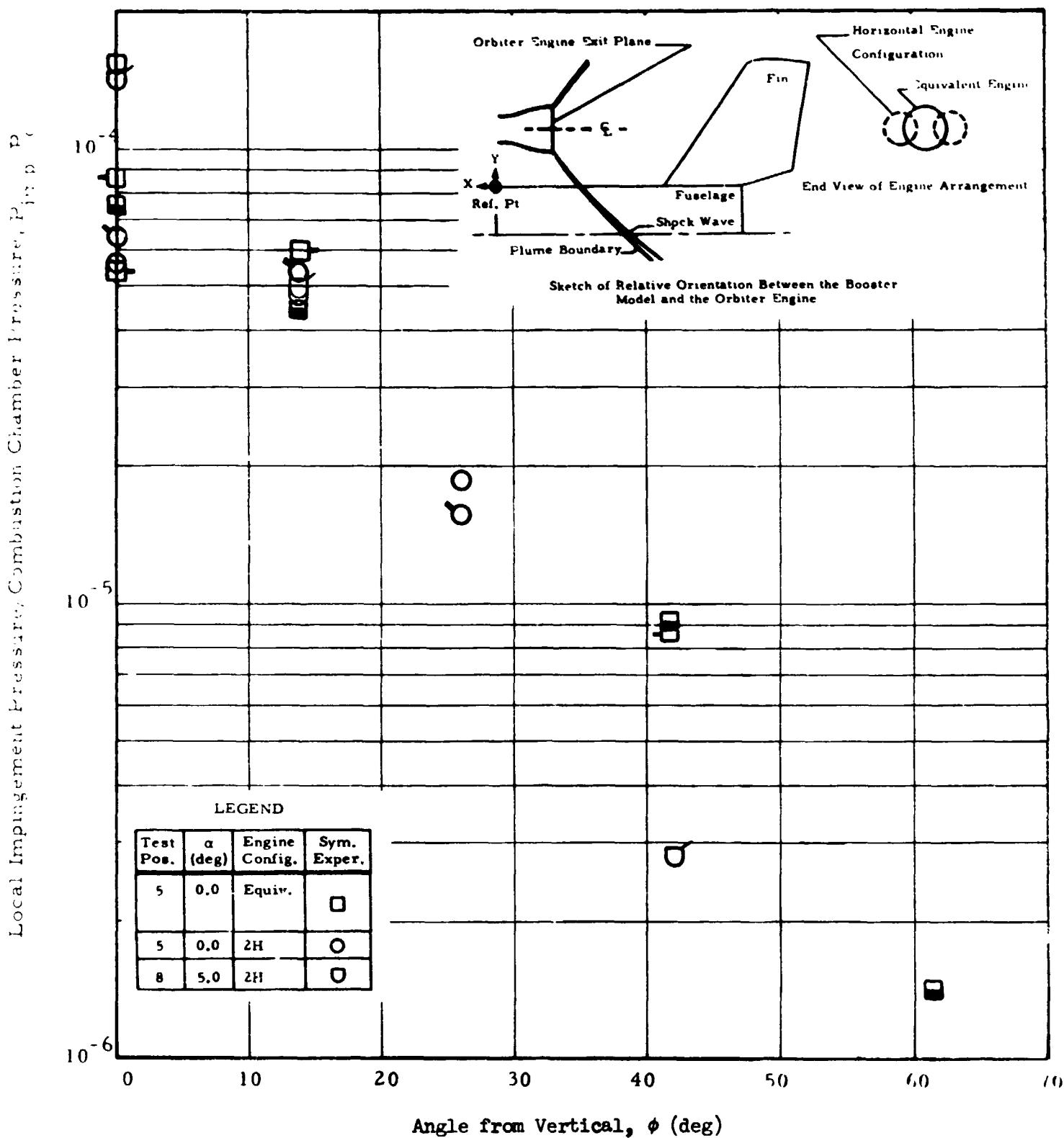


Fig. 61 - Impingement Pressure Distribution over the Booster Fuselage at Station 96.12 (Test Pos. 5 and Test Pos. 8)

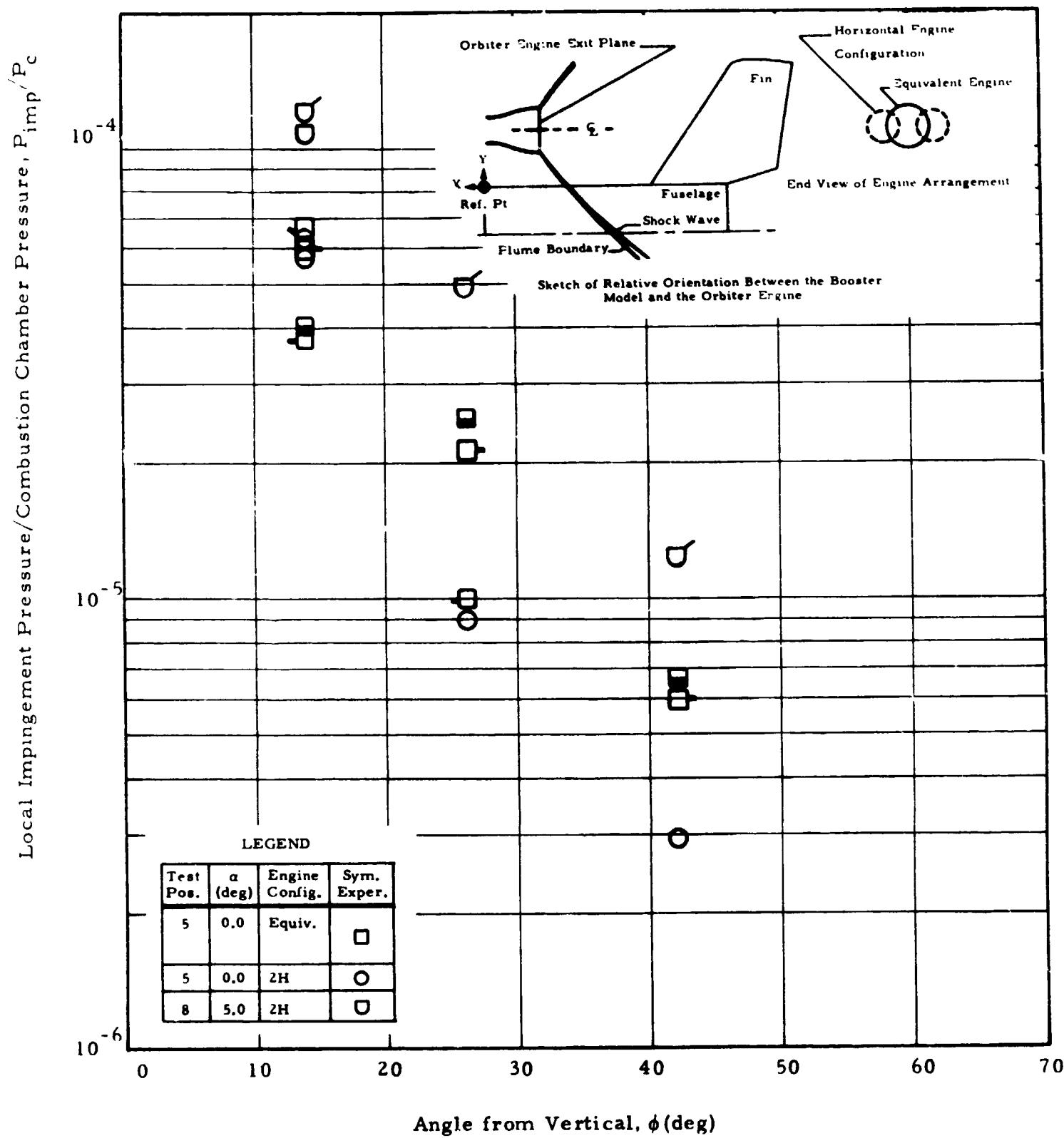


Fig. 62 - Impingement Pressure Distribution over the Booster Fuselage at Station 99.12 (Test Pos. 5 and Test Pos. 8)

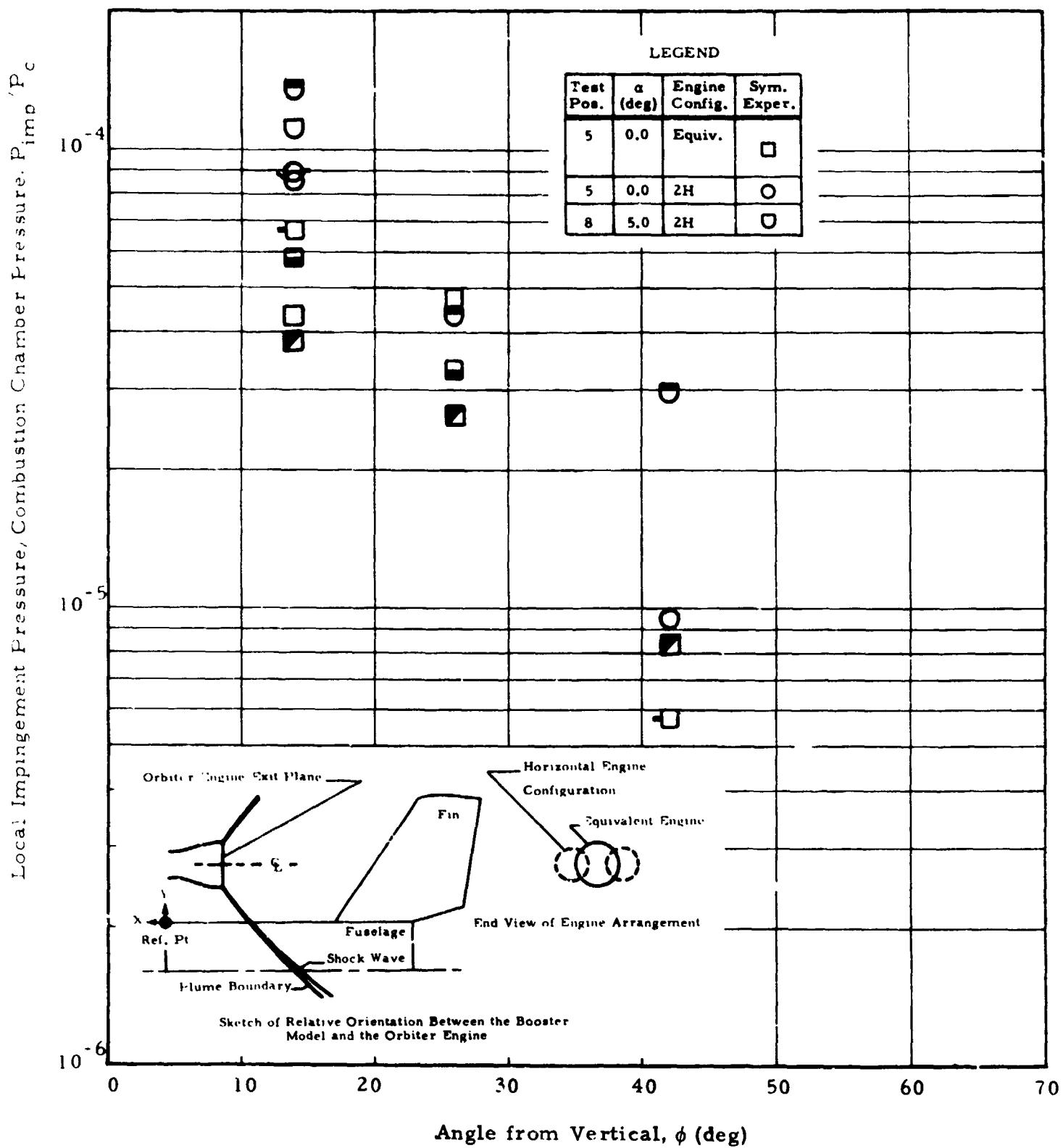


Fig. 63 - Impingement Pressure Distribution over the Booster Fuselage at Station 102.12 (Test Pos. 5 and Test Pos. 8)

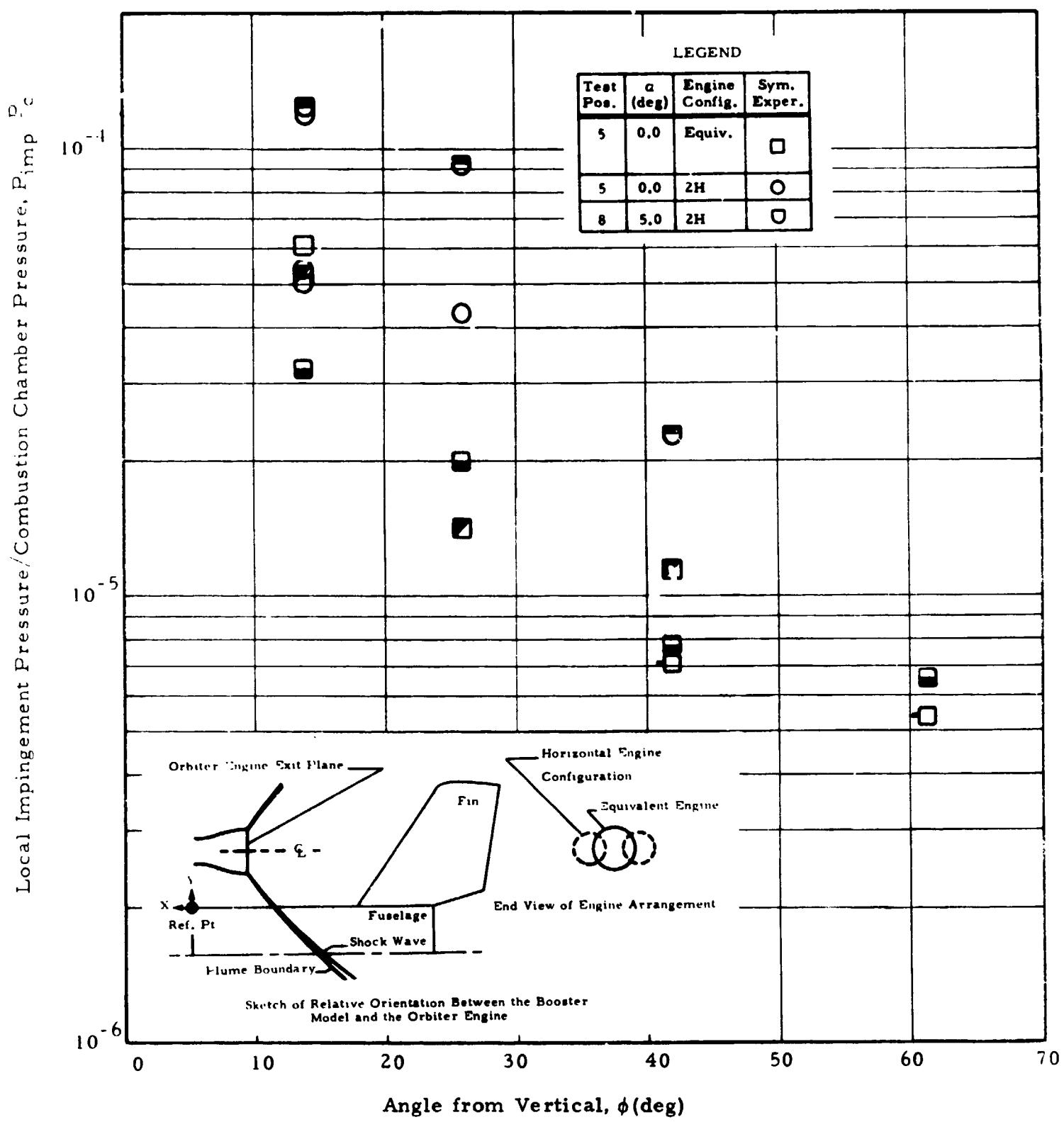


Fig. 64 - Impingement Pressure Distribution over the Booster Fuselage at Station 105.12 (Test Pos. 5 and Test Pos. 8)

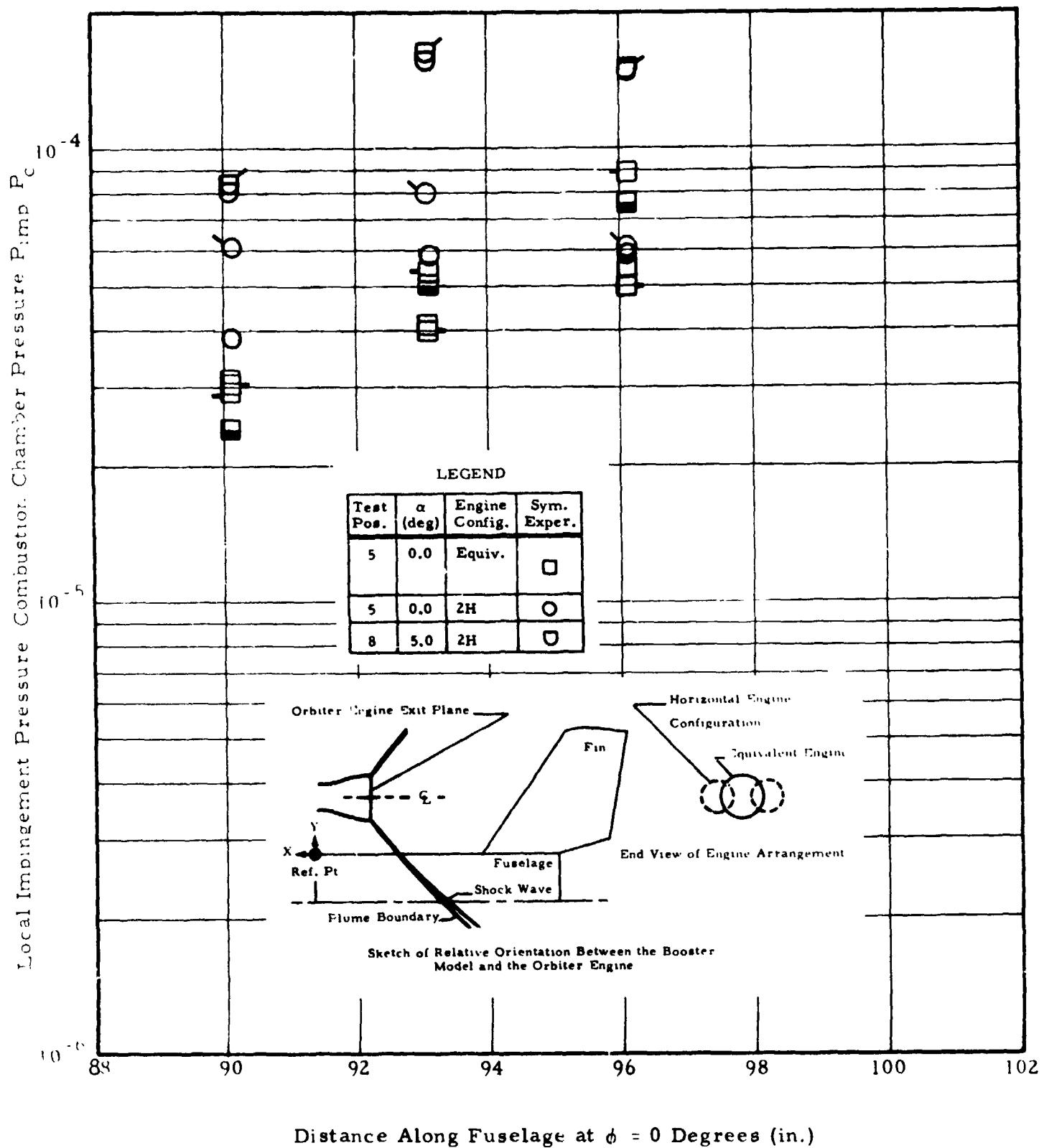


Fig. 65 - Impingement Pressure Distribution Along Fuselage Stagnation Line
(Test Pos. 5 and Test Pos. 8)

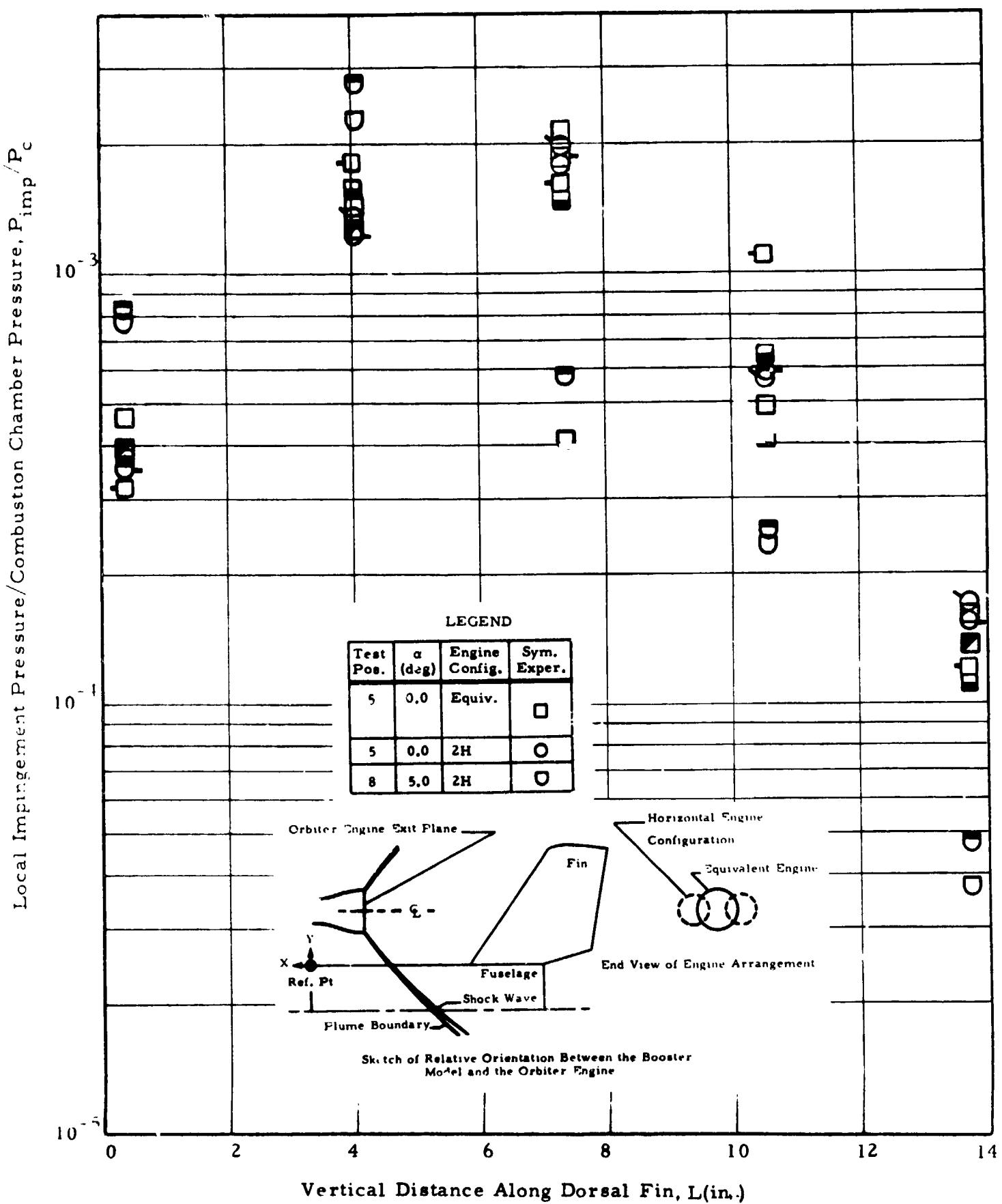


Fig. 66 - Impingement Pressure Distribution Along Dorsal Fin Leading Edge
(Test Positions 5 and 8)

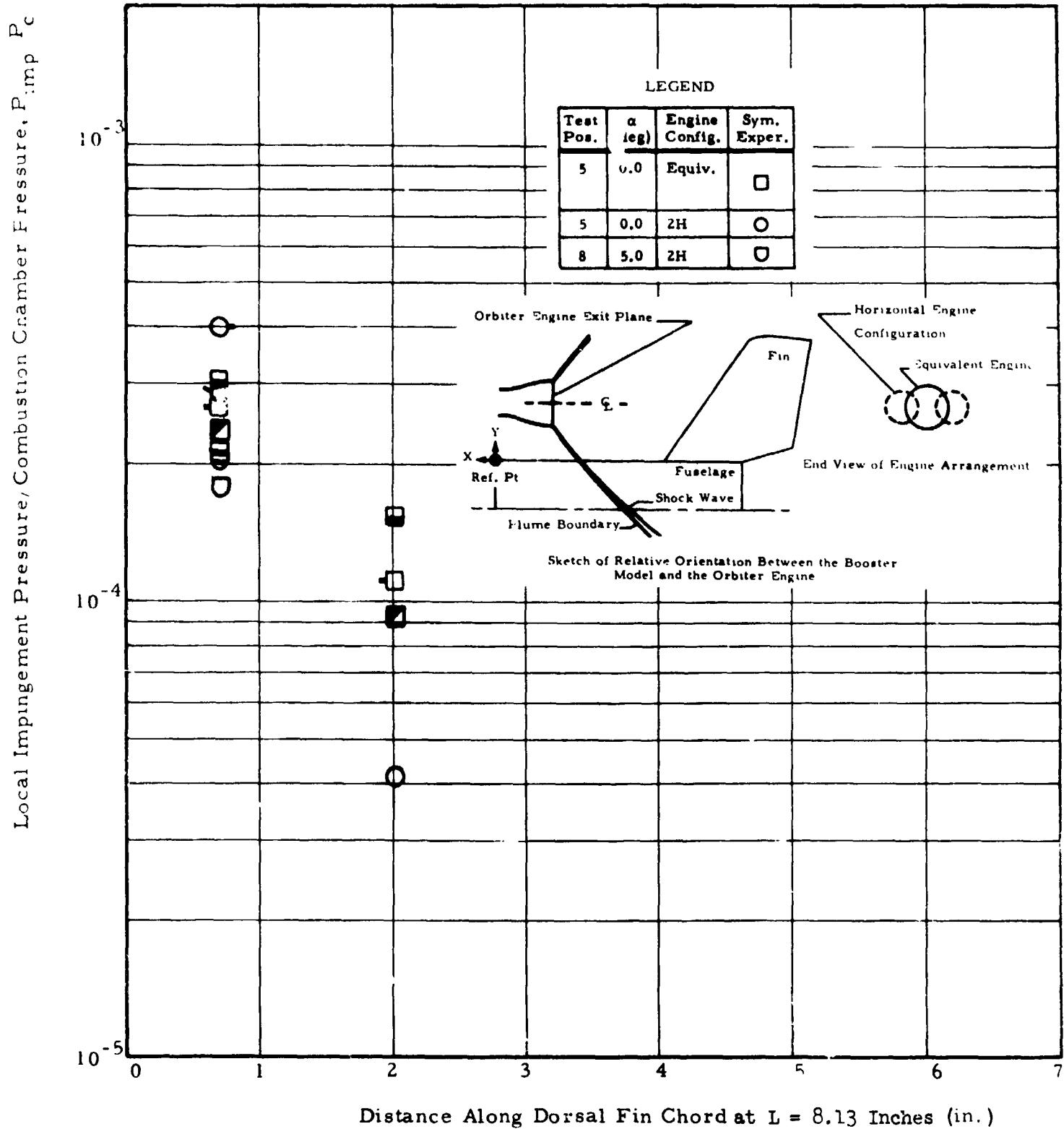


Fig. 67 - Impingement Pressure Distribution Along Dorsal Fin Chord (Test Pos. 5 and Test Pos. 8)

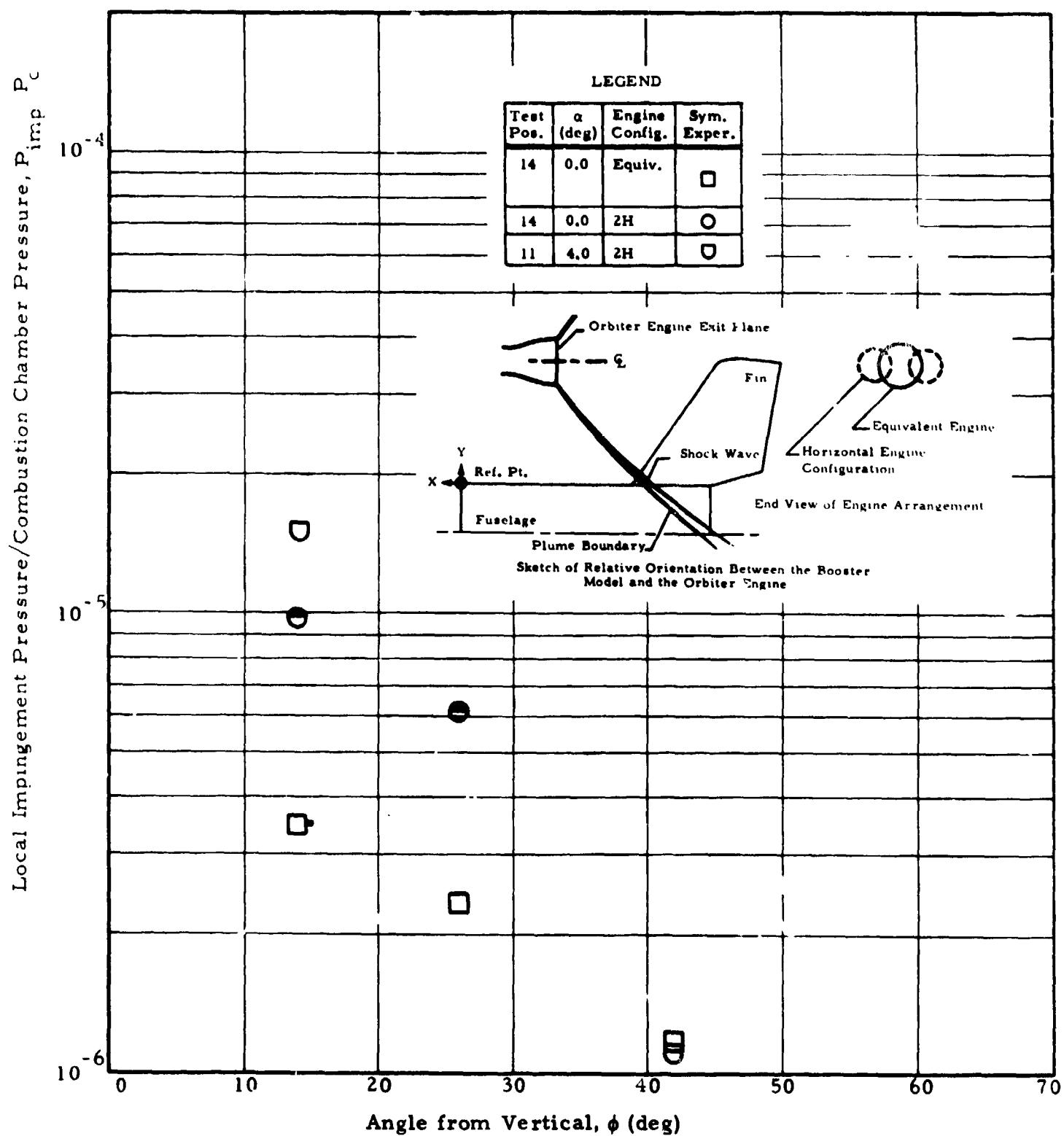


Fig. 68 - Impingement Pressure Distribution over the Booster Fuselage at Station 102.12 (Test Pos. 11 and Test Pos. 14)

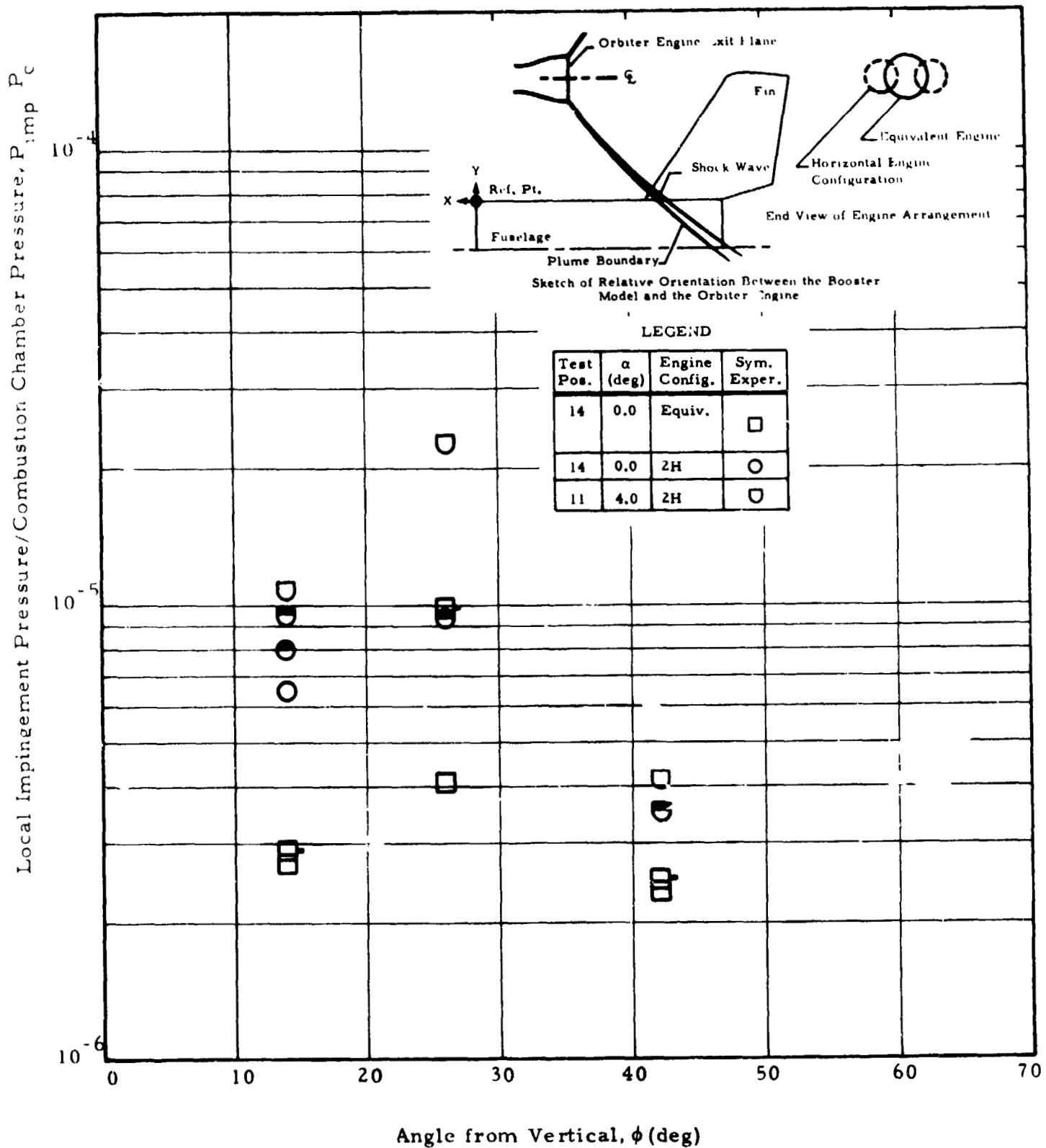


Fig. 69 - Impingement Pressure Distribution over the Booster Fuselage at Station 105.12 (Test Pos. 11 and Test Pos. 14)

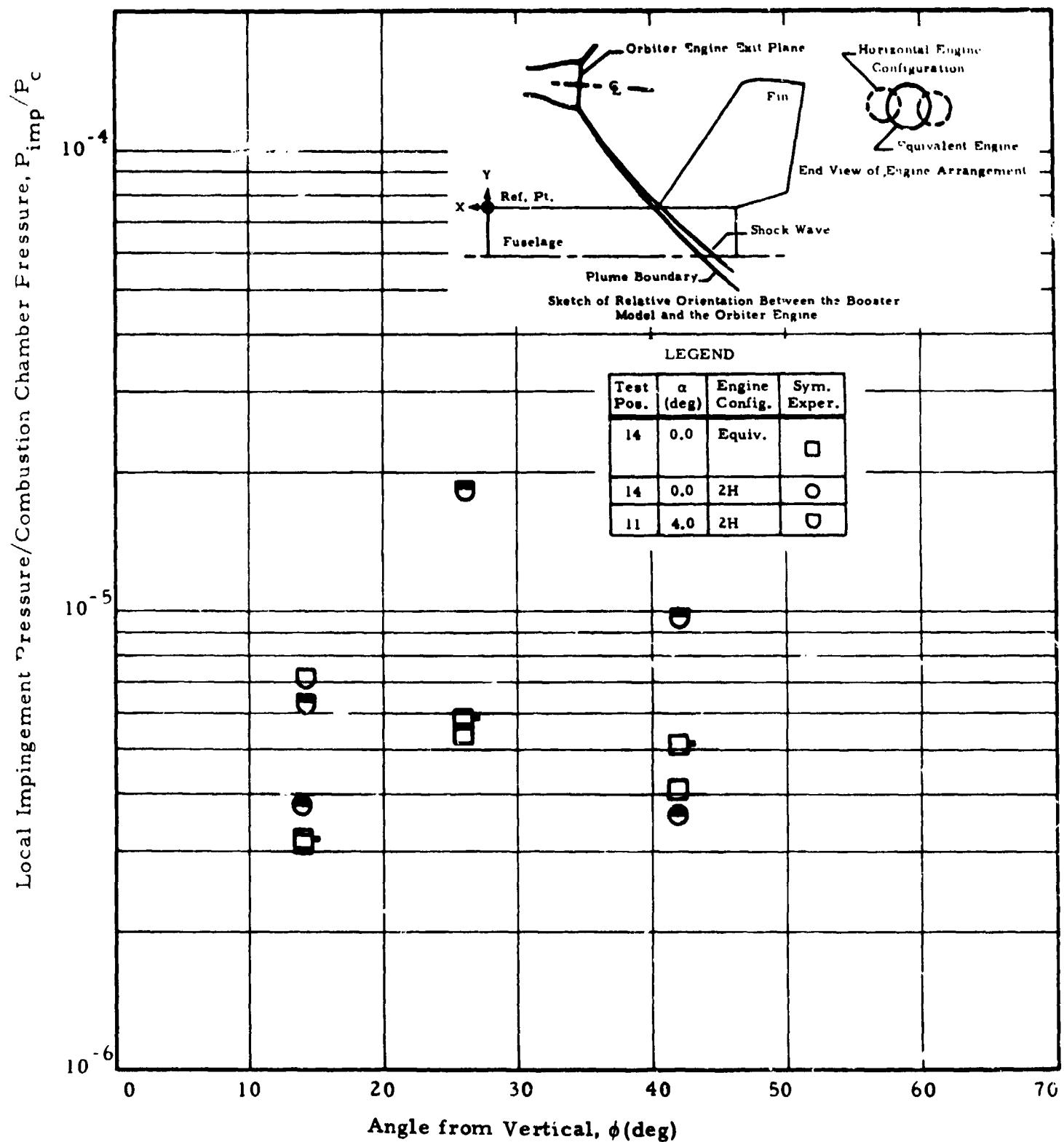


Fig. 70 - Impingement Pressure Distribution over the Booster Fuselage at Station 107.12 (Test Pos. 11 and Test Pos. 14)

LMSC-HREC D225839

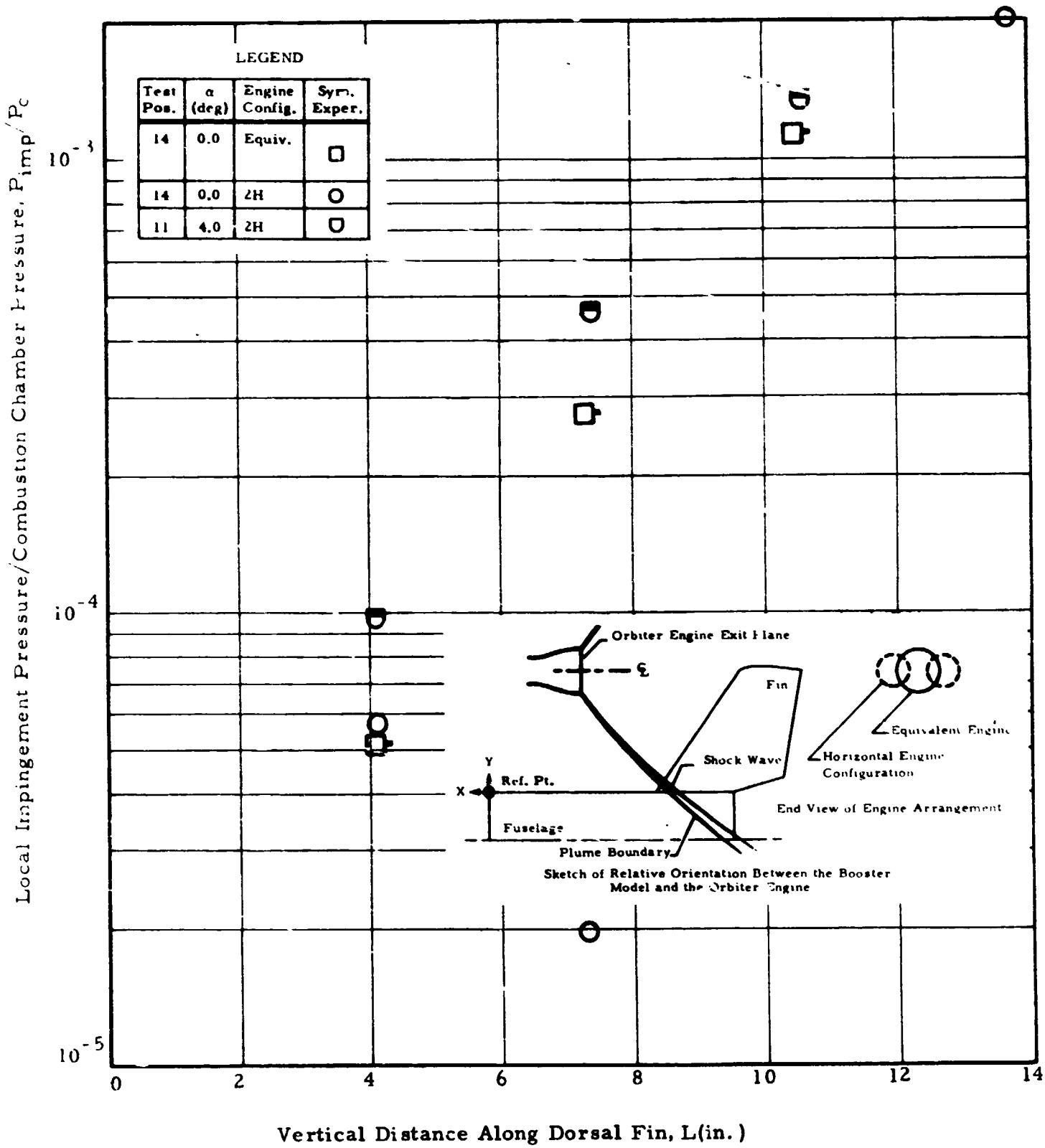


Fig. 71 - Impingement Pressure Distribution Along the Dorsal Fin Leading Edge (Test Pos 11 and Test Pos. 14)

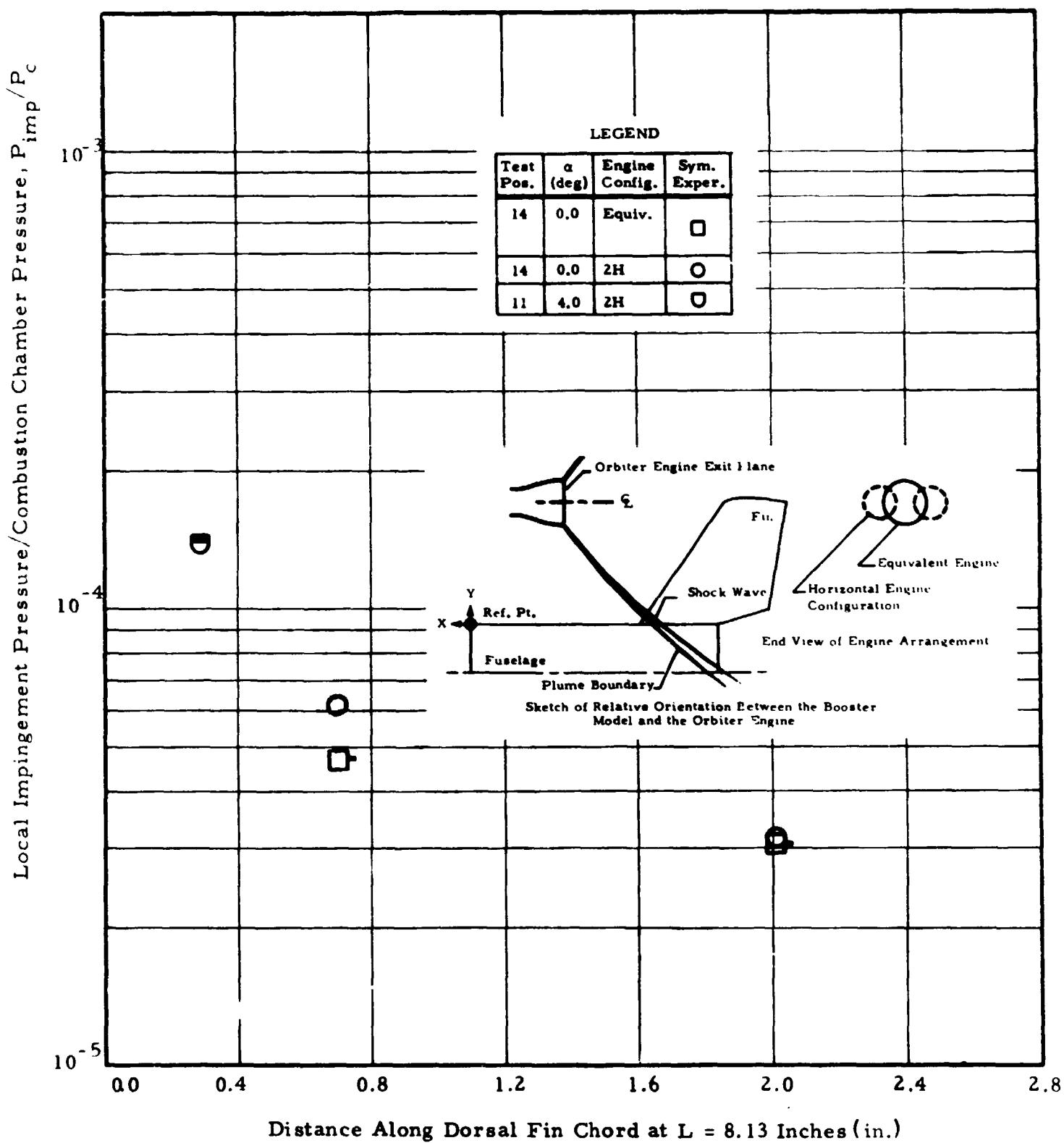


Fig. 72 - Impingement Pressure Distribution Along the Dorsal Fin Chord
(Test Pos. 11 and Test Pos. 14)

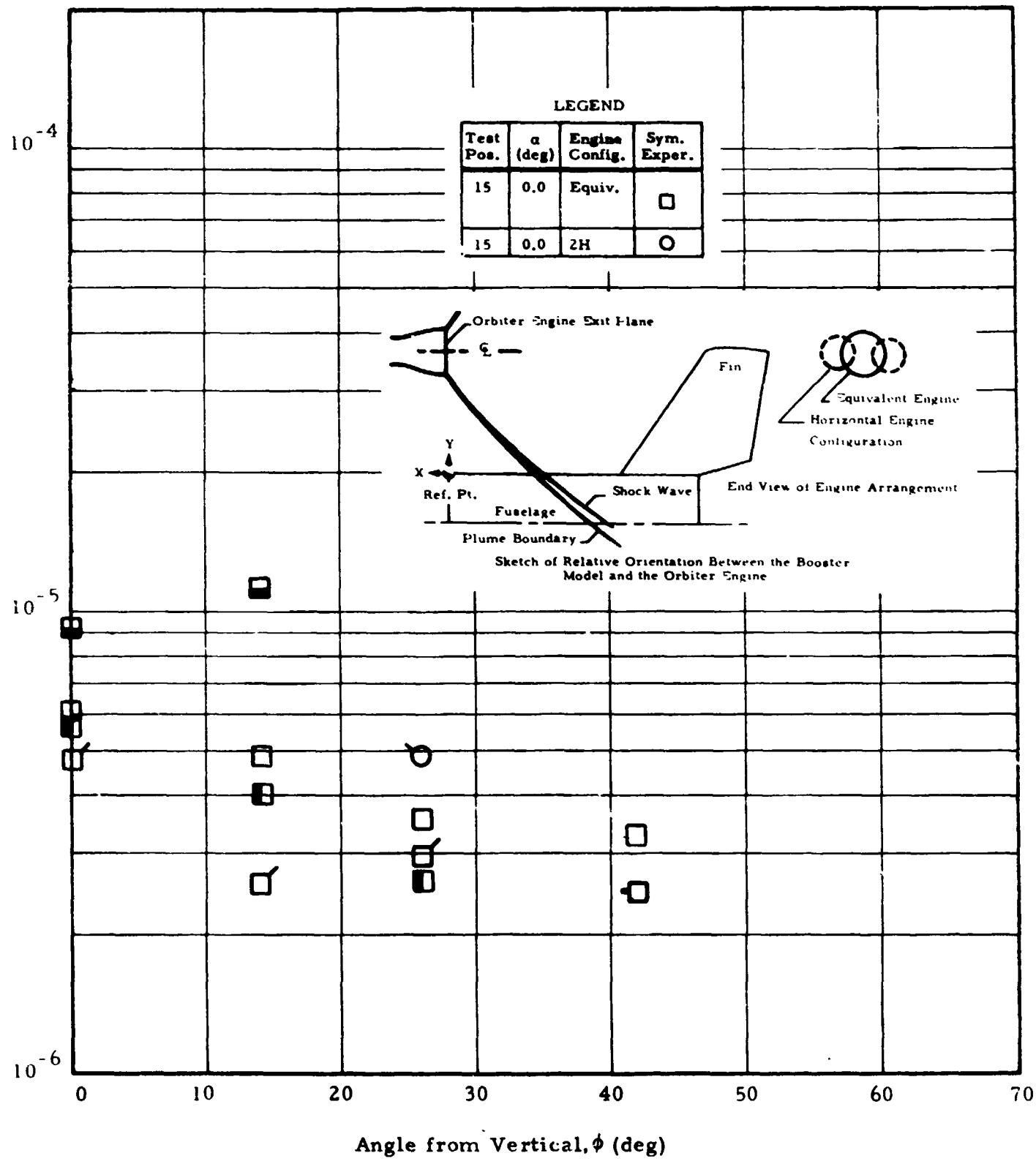
Local Impingement Pressure/Combustion Chamber Pressure P_{imp}/P_c 

Fig. 73 - Impingement Pressure Distribution over the Booster Fuselage at Station 93.12 (Test Pos. 15)

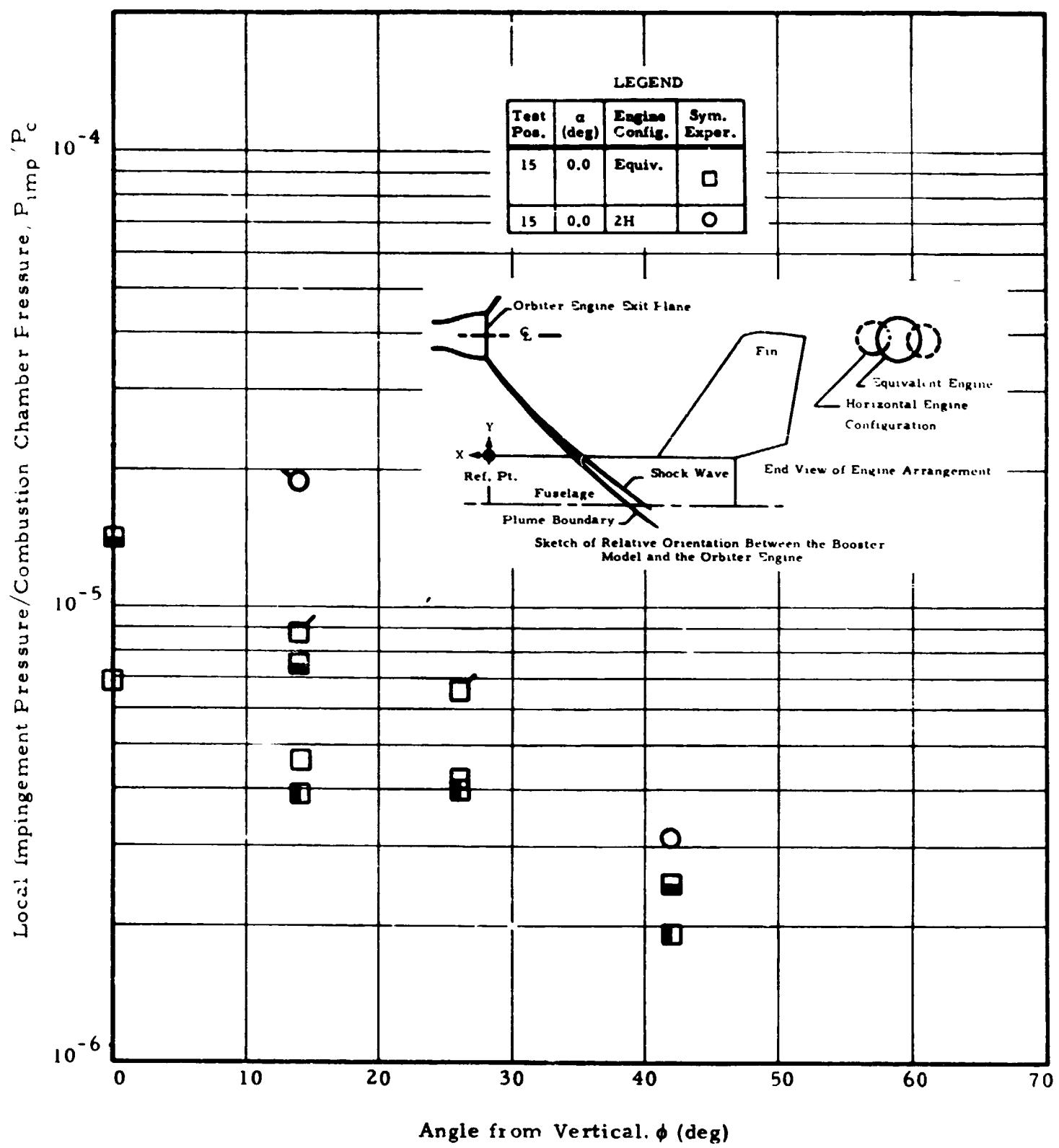


Fig. 74 - Impingement Pressure Distribution over the Booster Fuselage at Station 96.12 (Test Pos. 15)

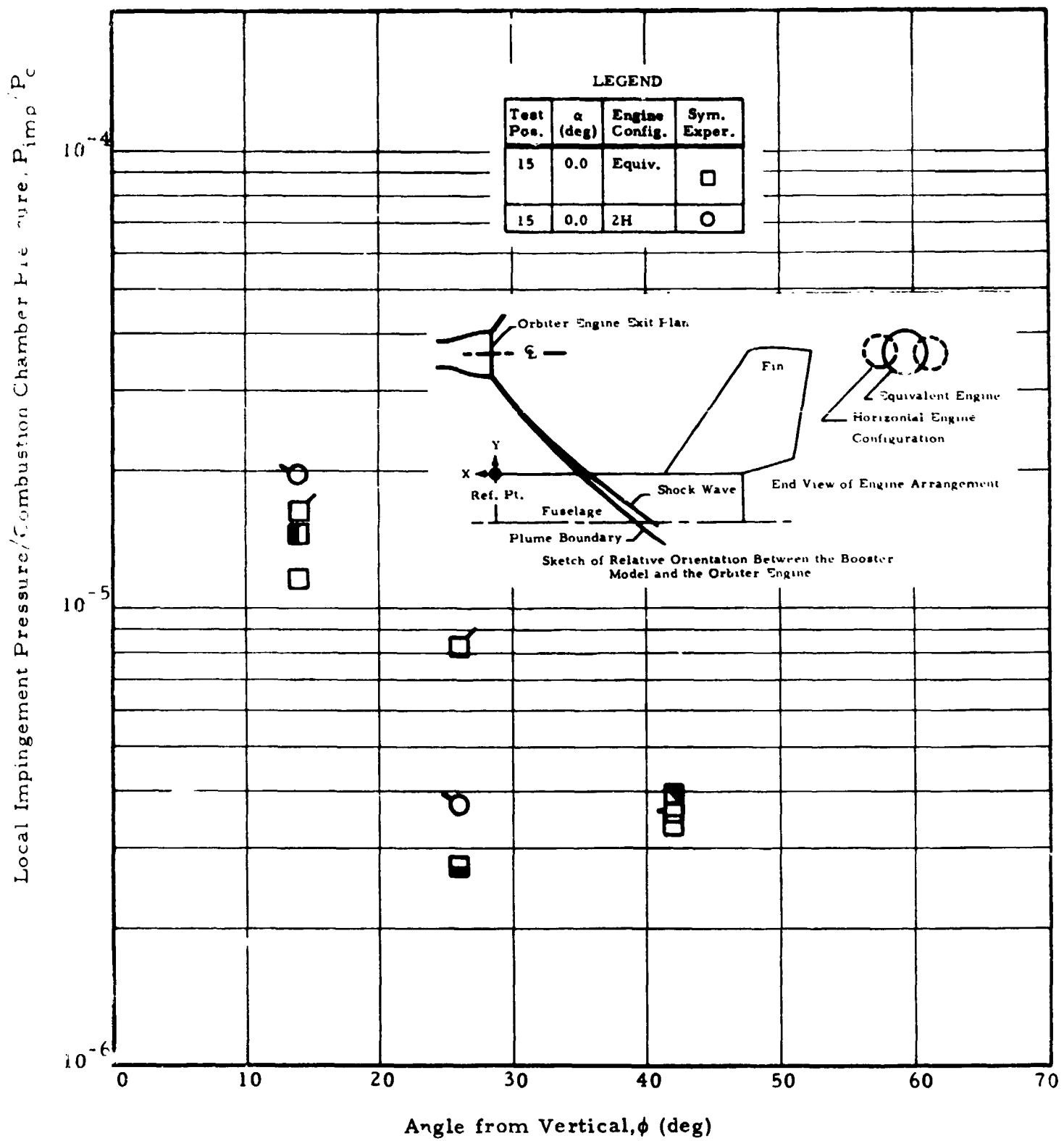


Fig. 75 - Impingement Pressure Distribution over the Booster Fuselage at Station 99.12 (Test Pos. 15)

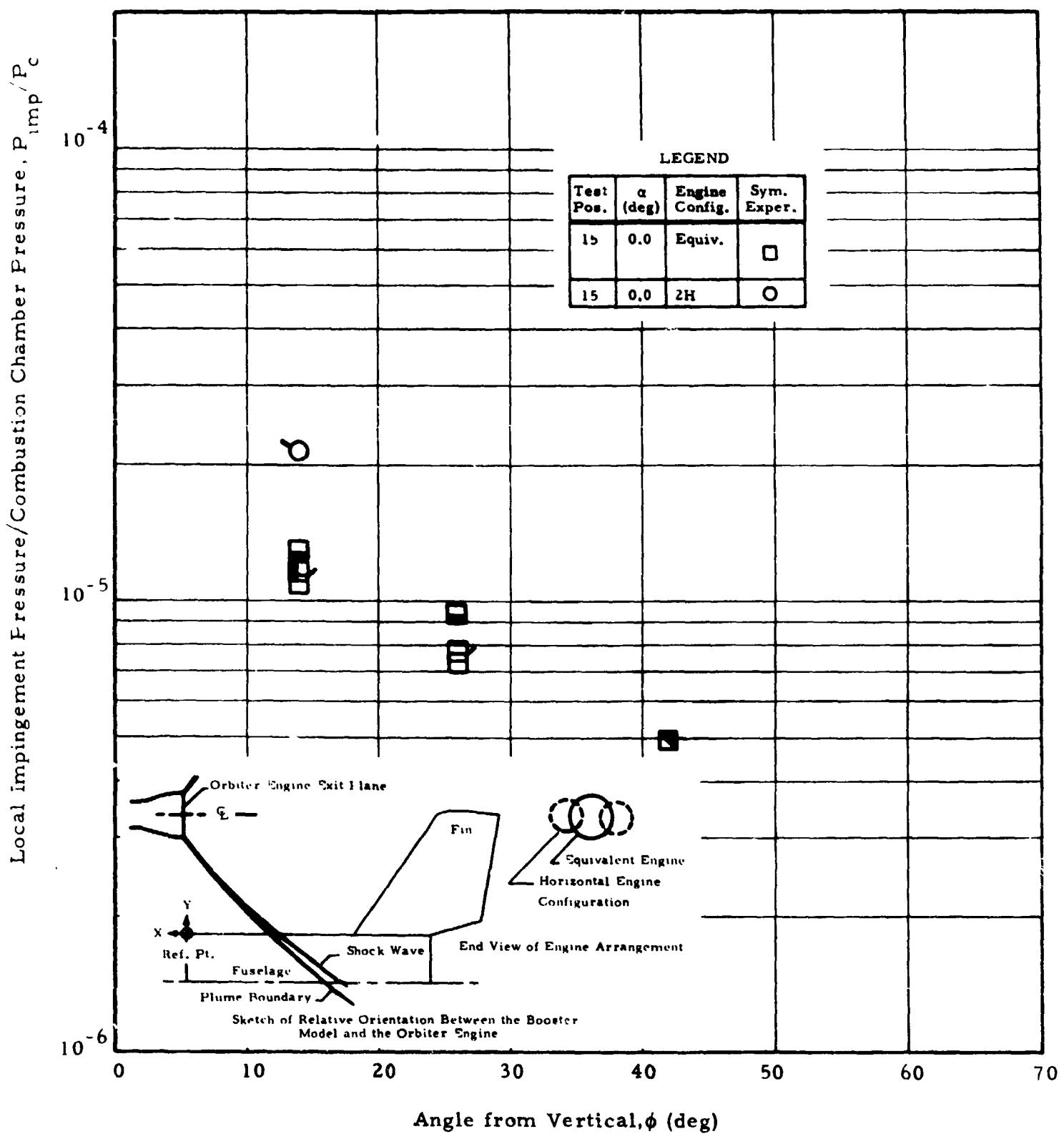


Fig. 76 - Impingement Pressure Distribution over the Booster Fuselage at Station 102.12 (Test Pos. 15)

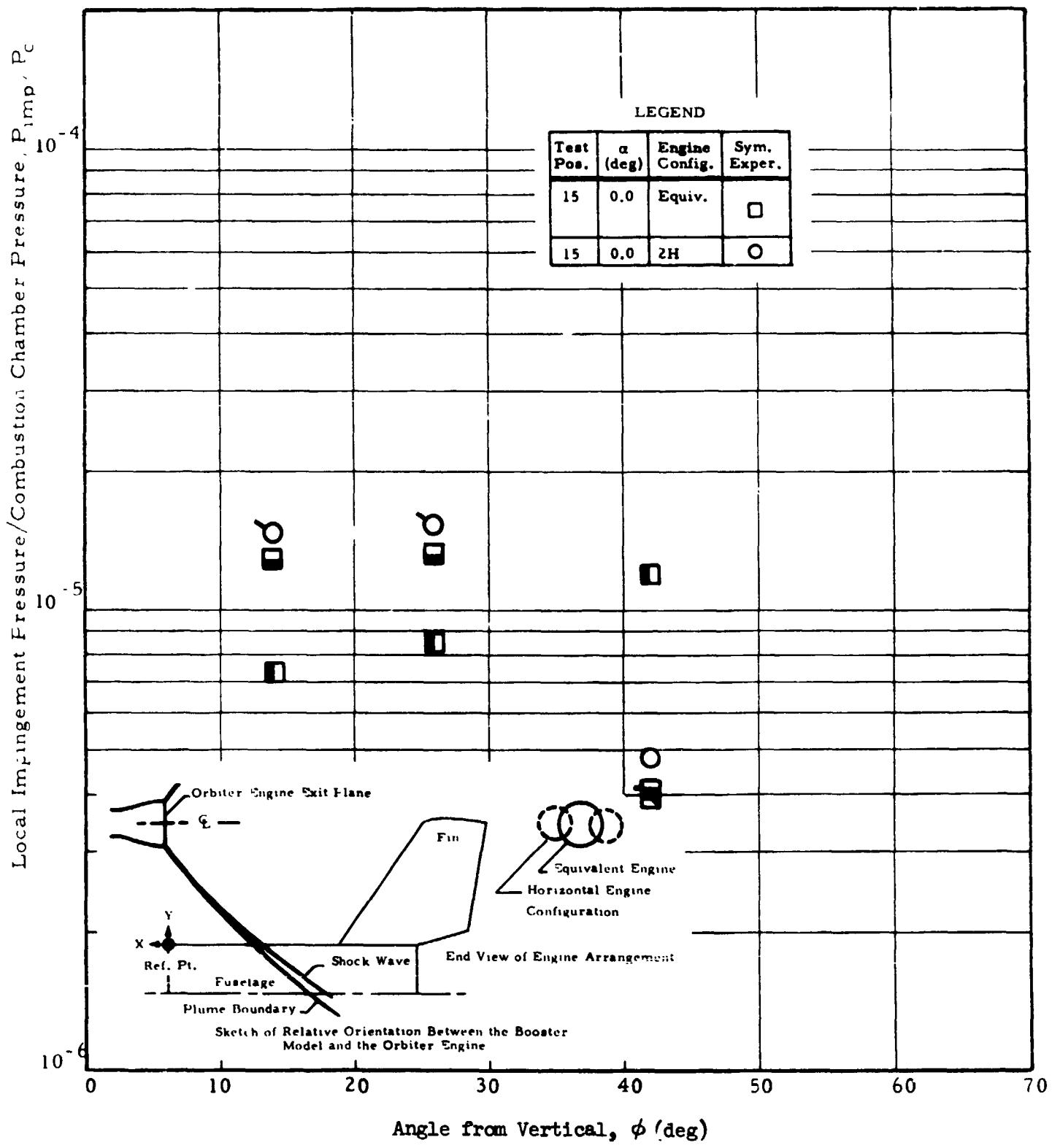


Fig. 7.7 - Impingement Pressure Distribution over the Booster Fuselage at Station 105.12 (Test Pos. 15)

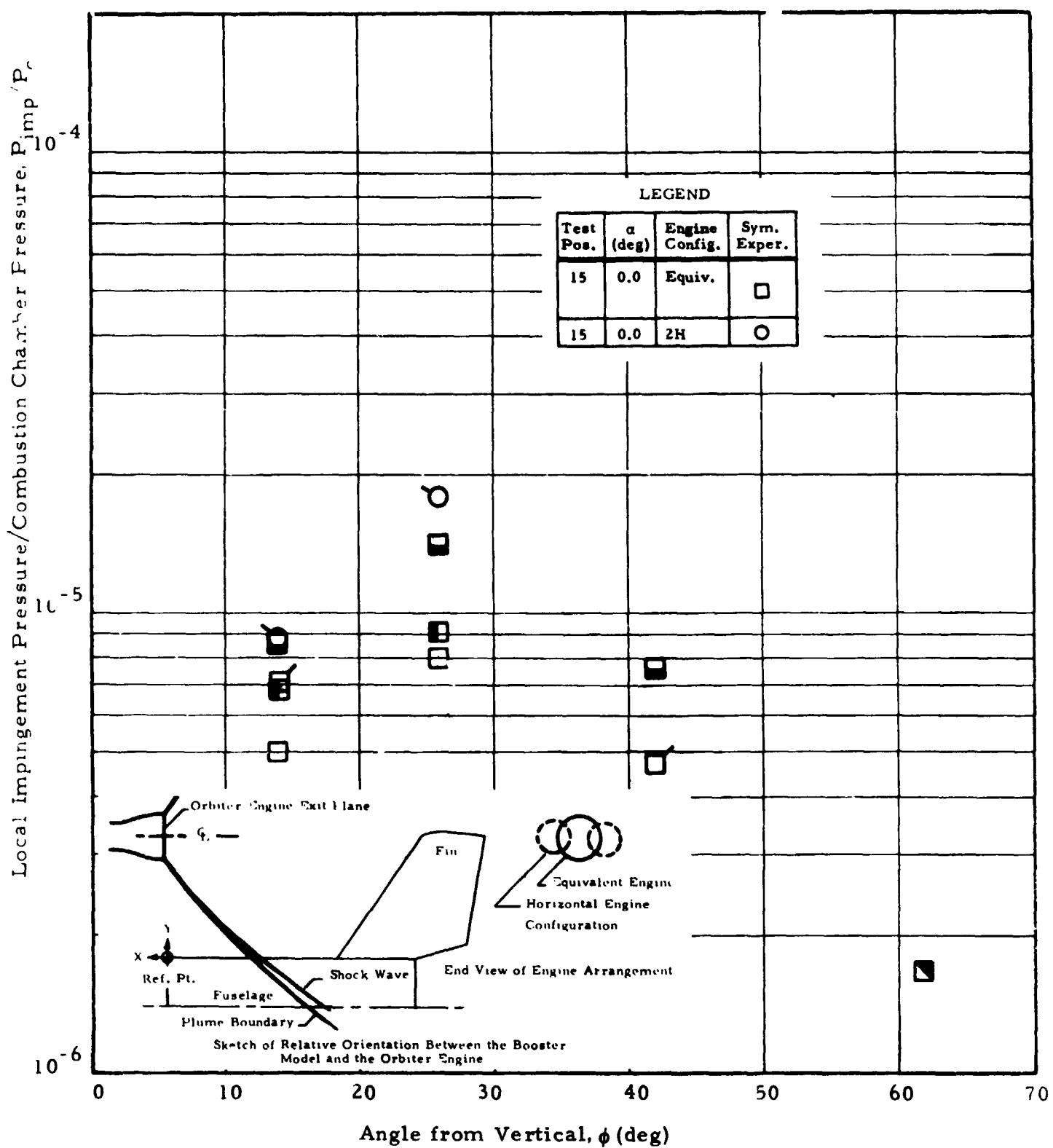


Fig. 78 - Impingement Pressure Distribution over the Booster Fuselage
at Station 107.12 (Test Pos. 15)

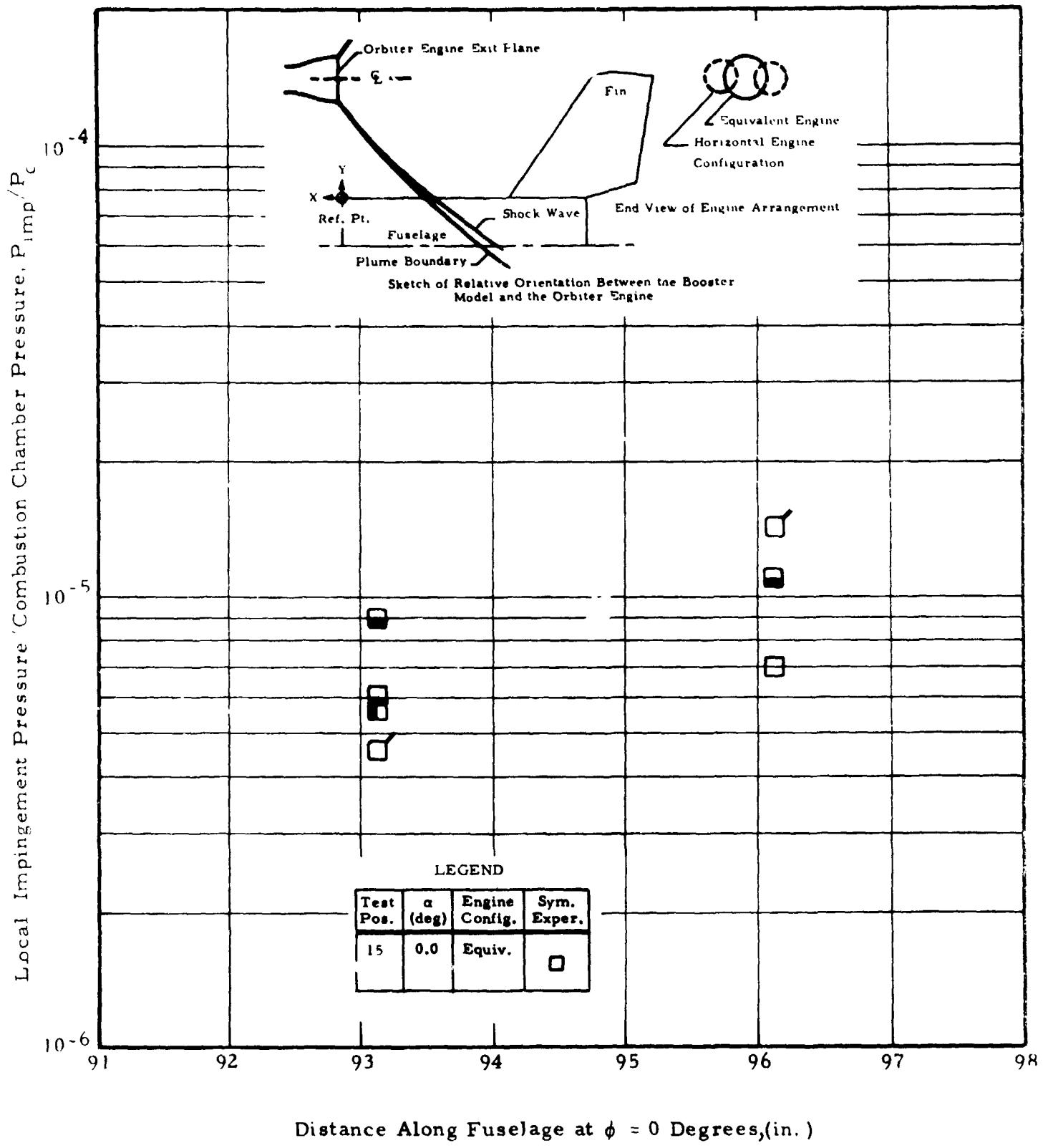


Fig. 79 - Impingement Pressure Distribution Along Fuselage Stagnation Line
(Test Pos. 15)

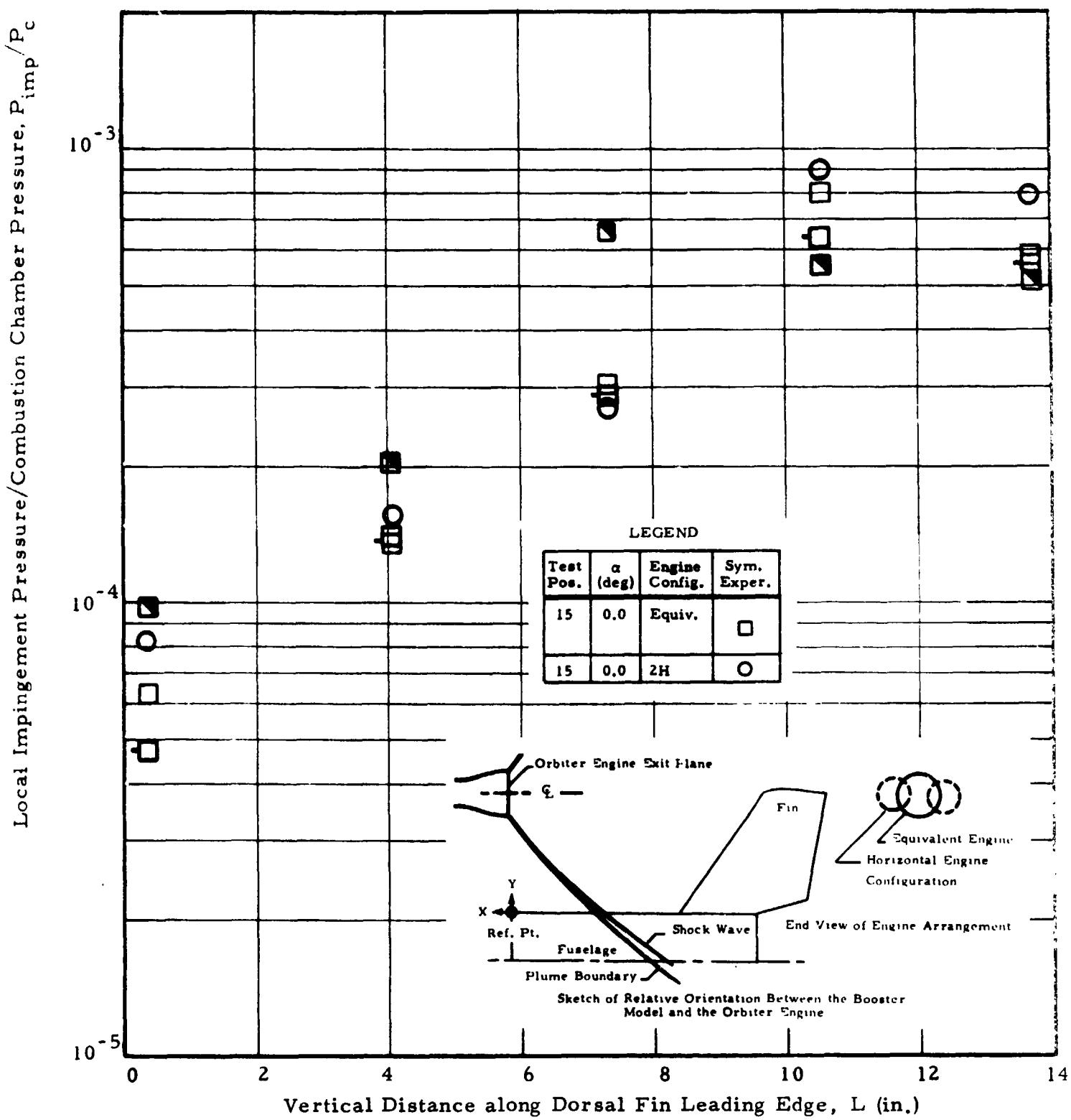


Fig. 80 - Impingement Pressure Distribution along the Dorsal Fin Leading Edge (Test Pos. 15)

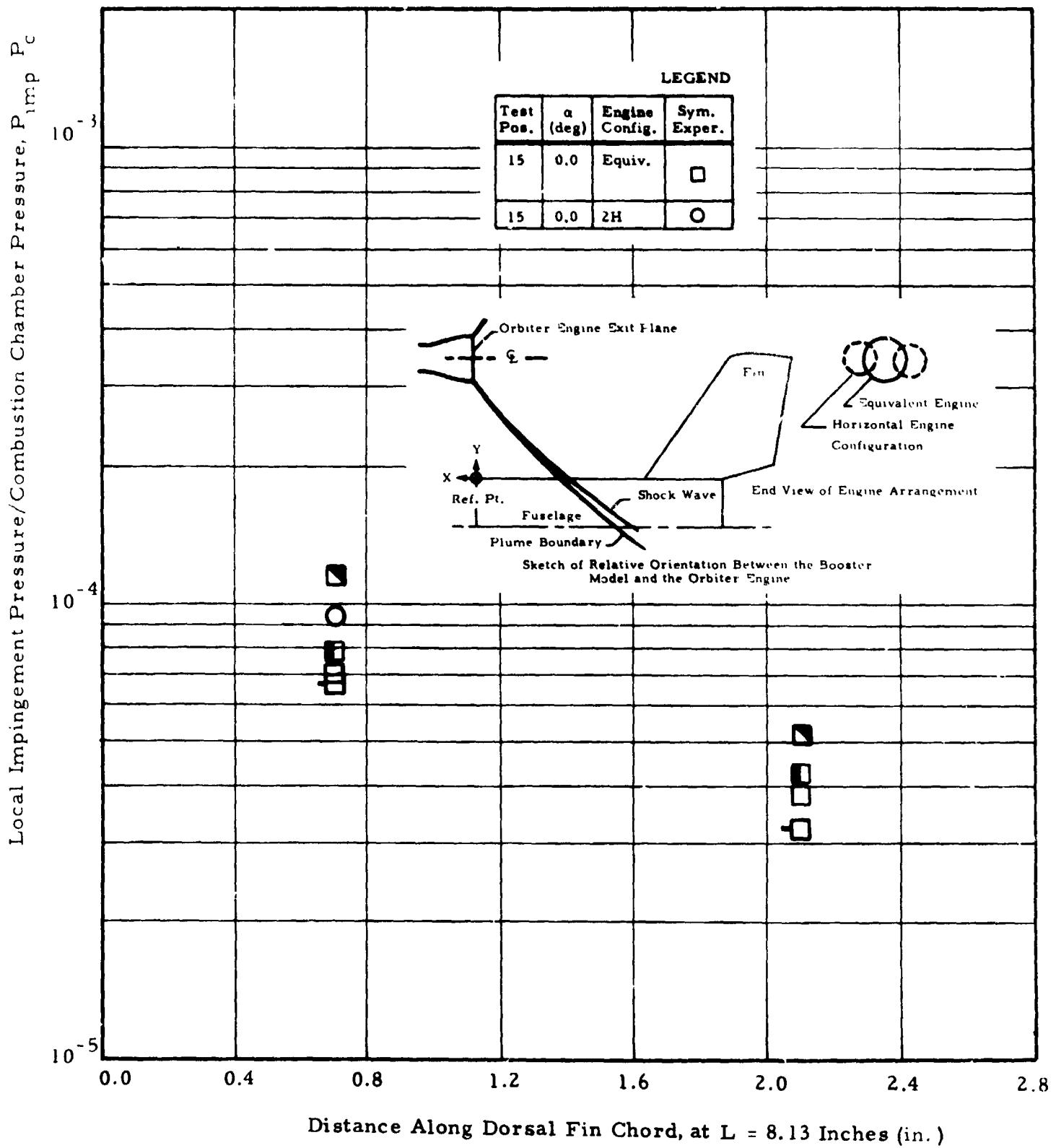


Fig. 81 - Impingement Pressure Distribution along the Dorsal Fin Chord (Test Pos. 15)

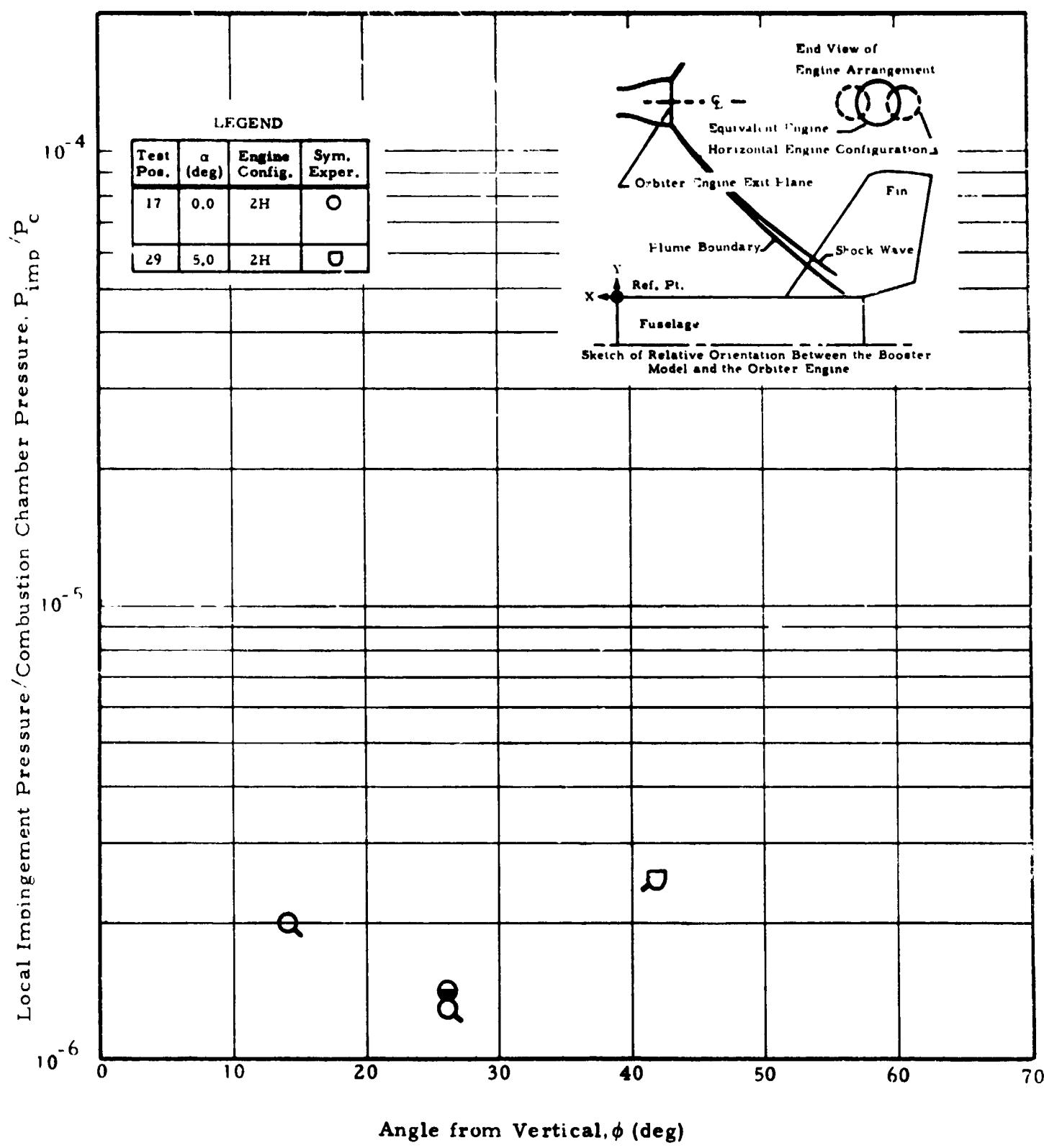


Fig. 82 - Impingement Pressure Distribution over the Booster Fuselage at Station 107.12 (Test Positions 17 and 29)

LMSC-HREC D225839

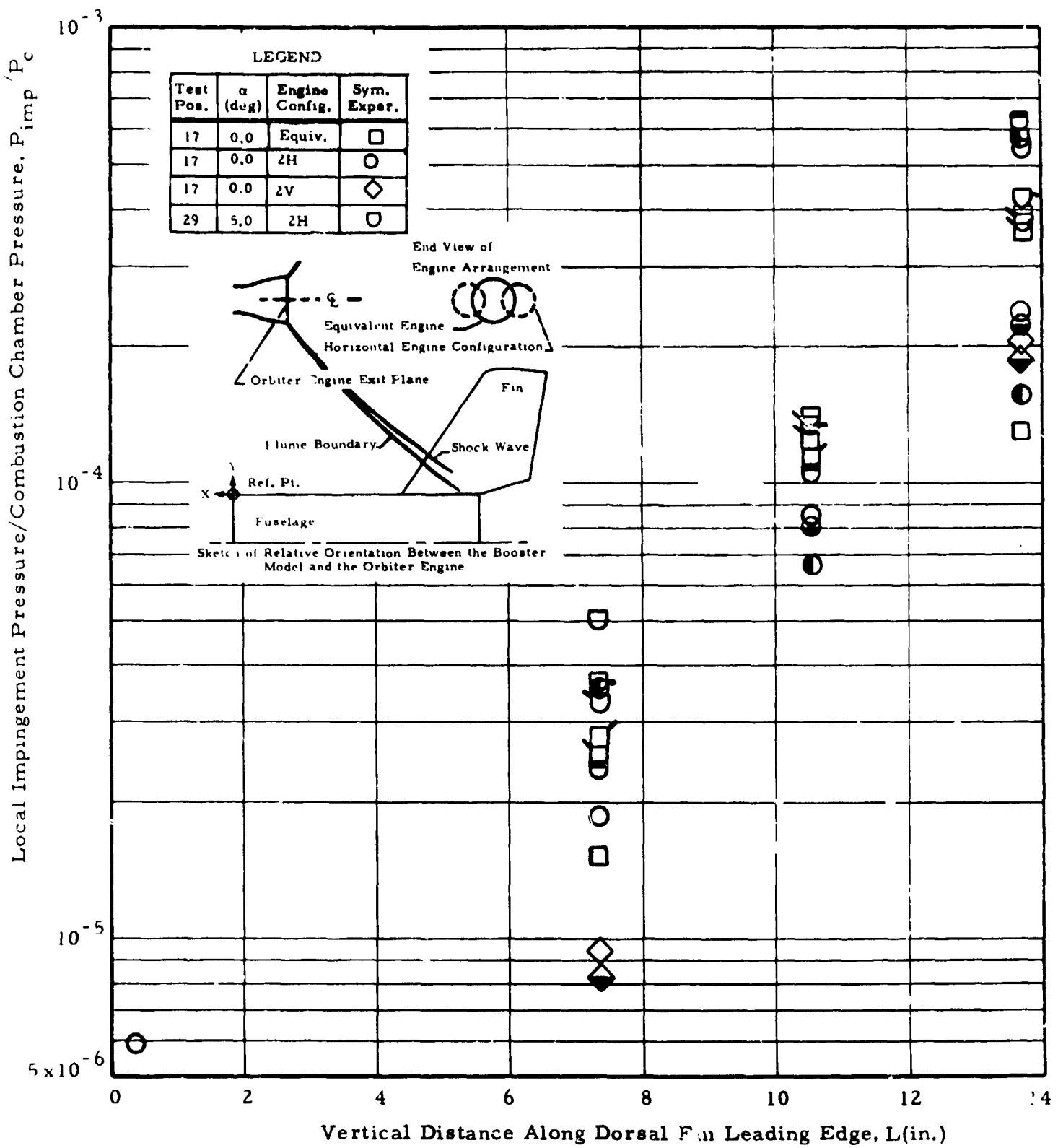


Fig. 83 - Impingement Pressure Distribution Along the Dorsal Fin Leading Edge (Test Pos. 17 and Test Pos. 29)

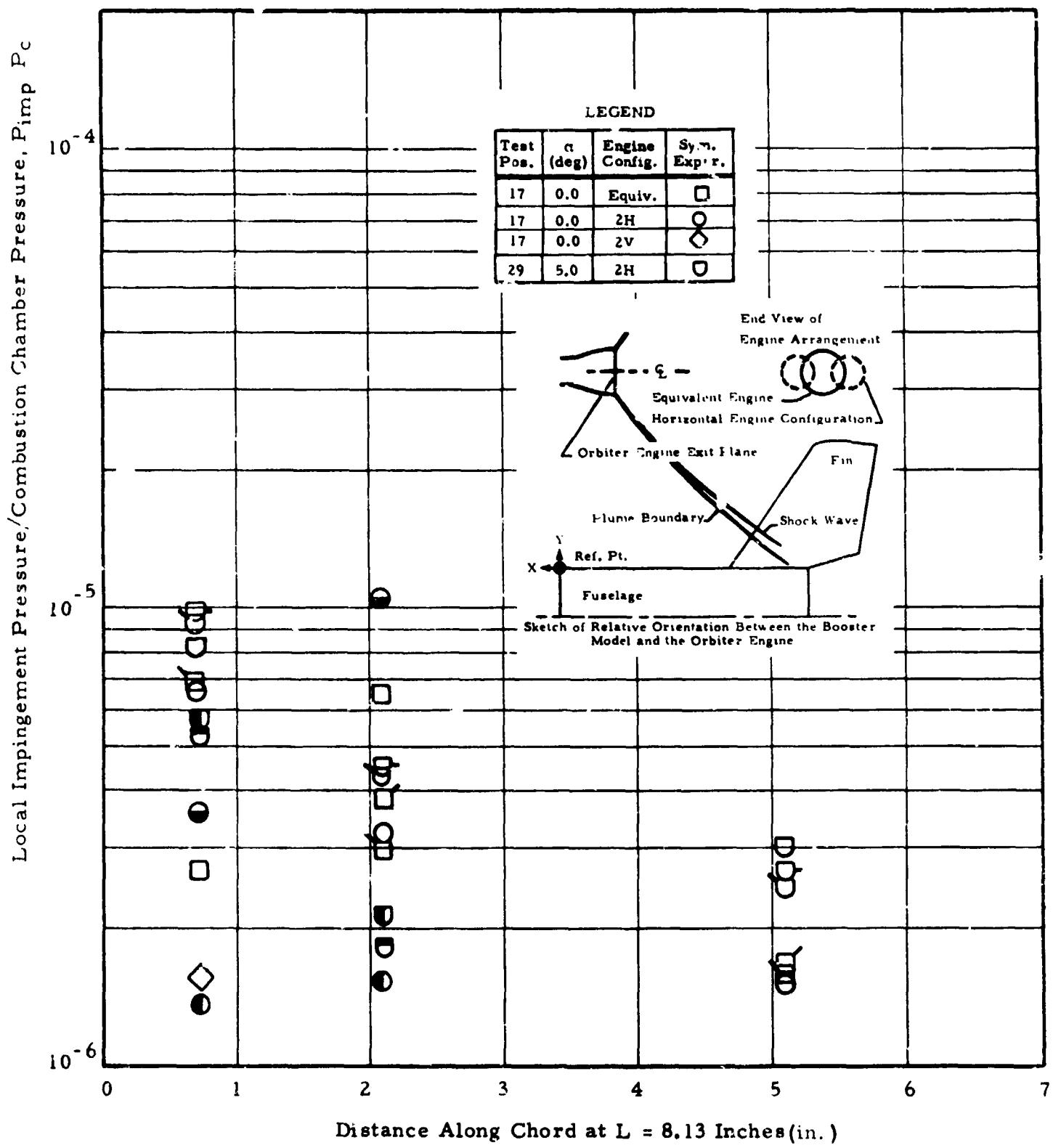


Fig. 84 - Impingement Pressure Distribution Along the Dorsal Fin Chord
(Test Pos. 17 and Test Pos. 29)

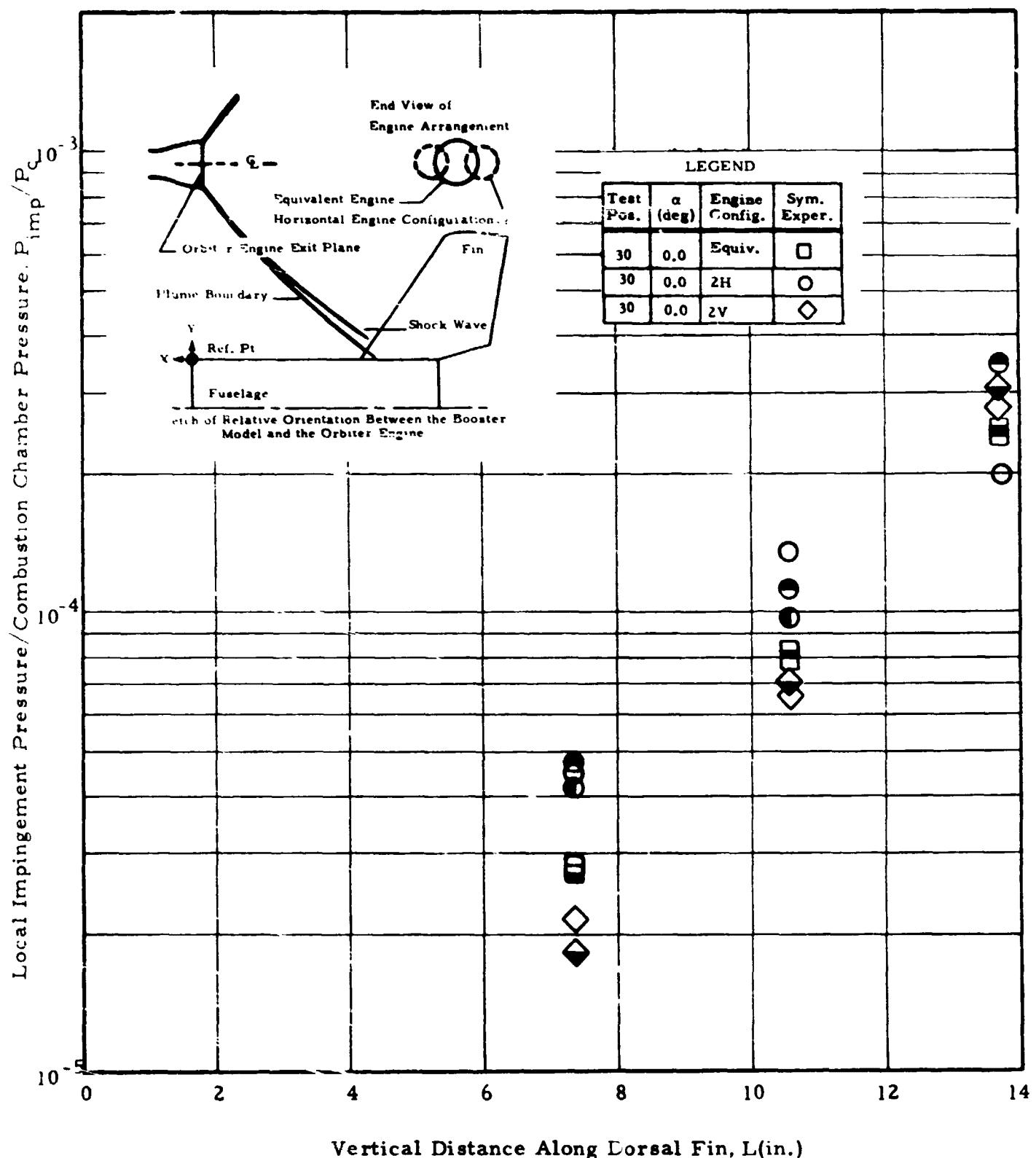


Fig. 85 - Impingement Pressure Distribution Along the Dorsal Fin Leading Edge (Test Pos. 30)

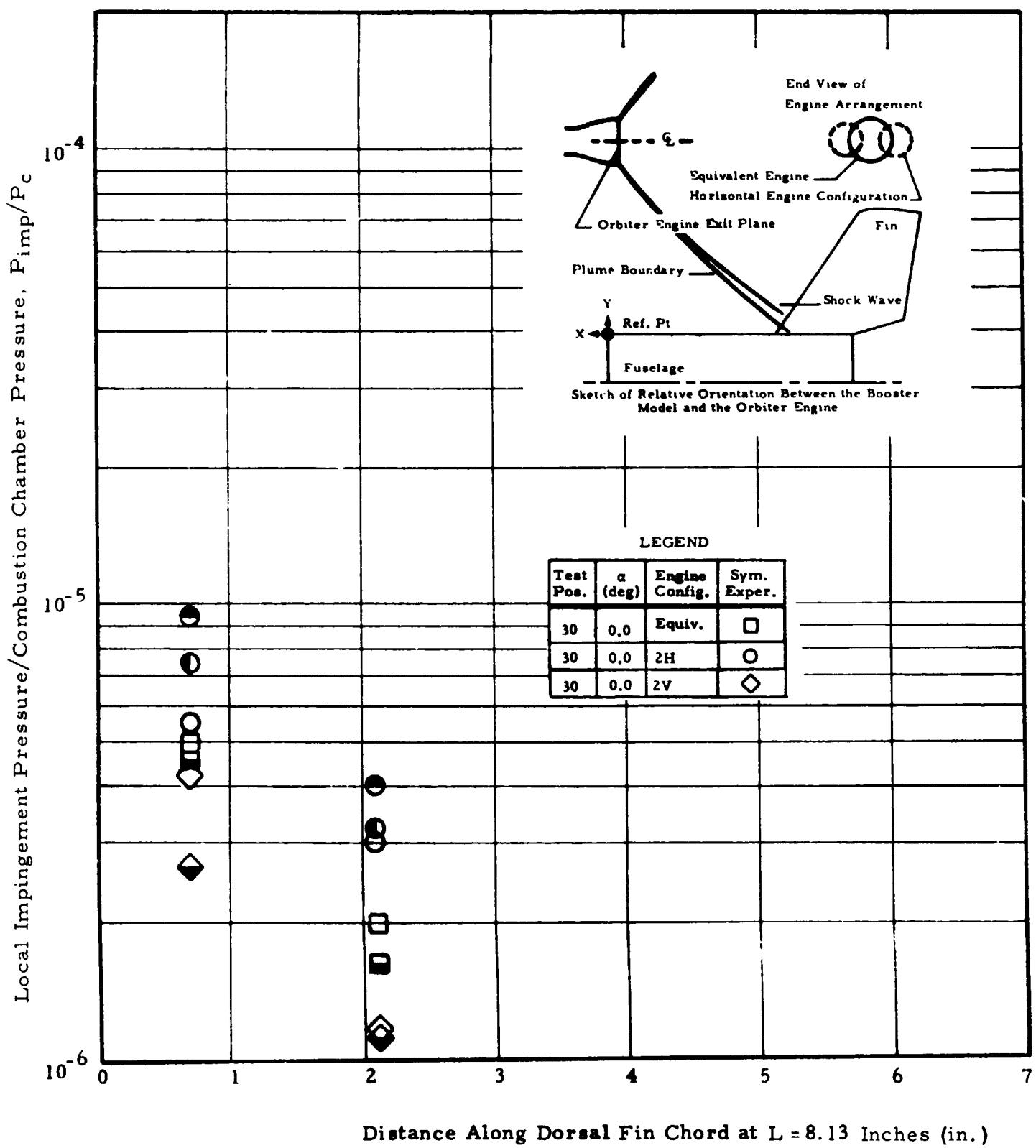


Fig. 86 - Impingement Pressure Distribution Along the Dorsal Fin Chord
(Test Pos. 30)

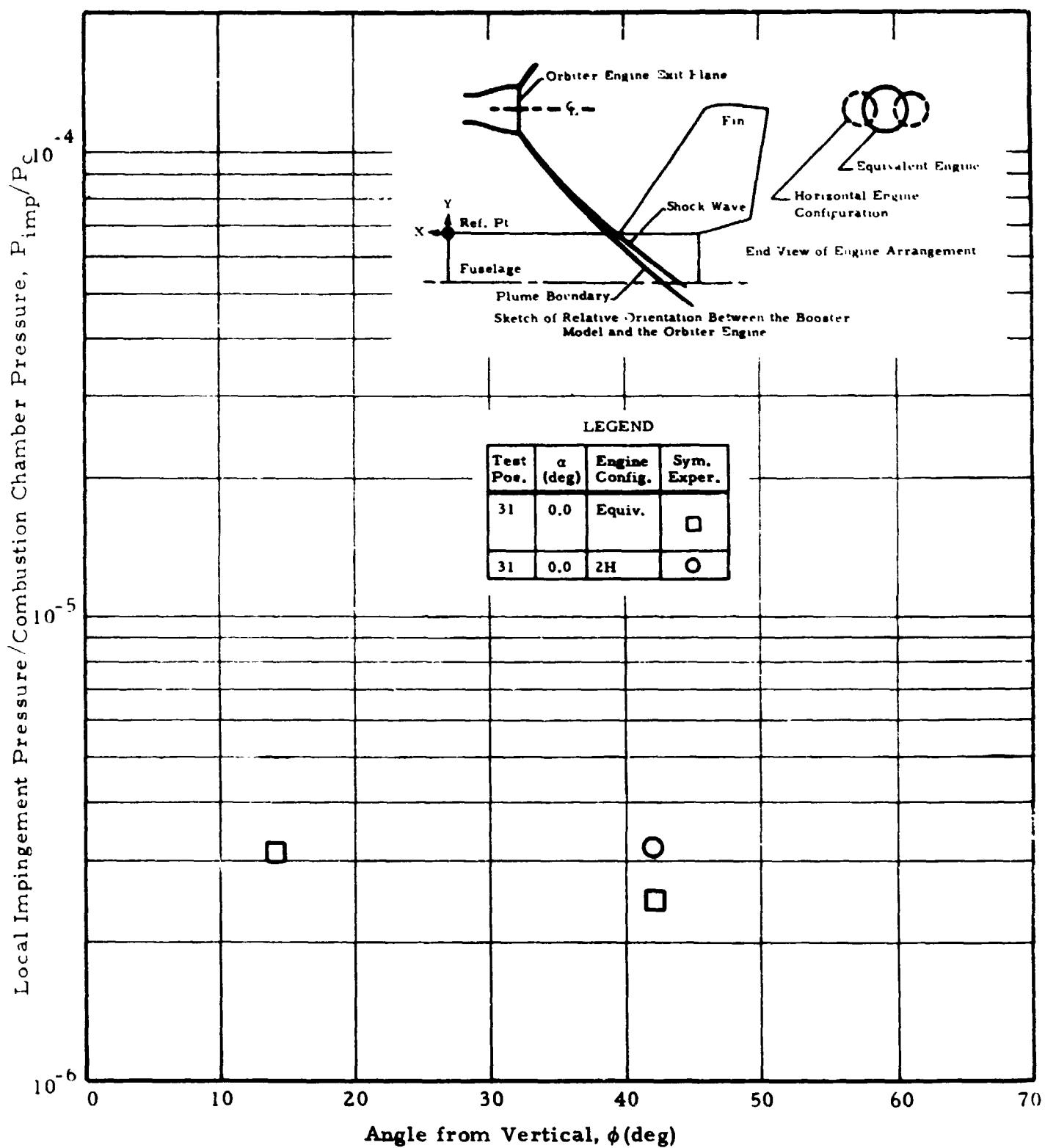


Fig. 87 - Impingement Pressure Distribution over the Booster Fuselage at Station 105.12 (Test Pos. 31)

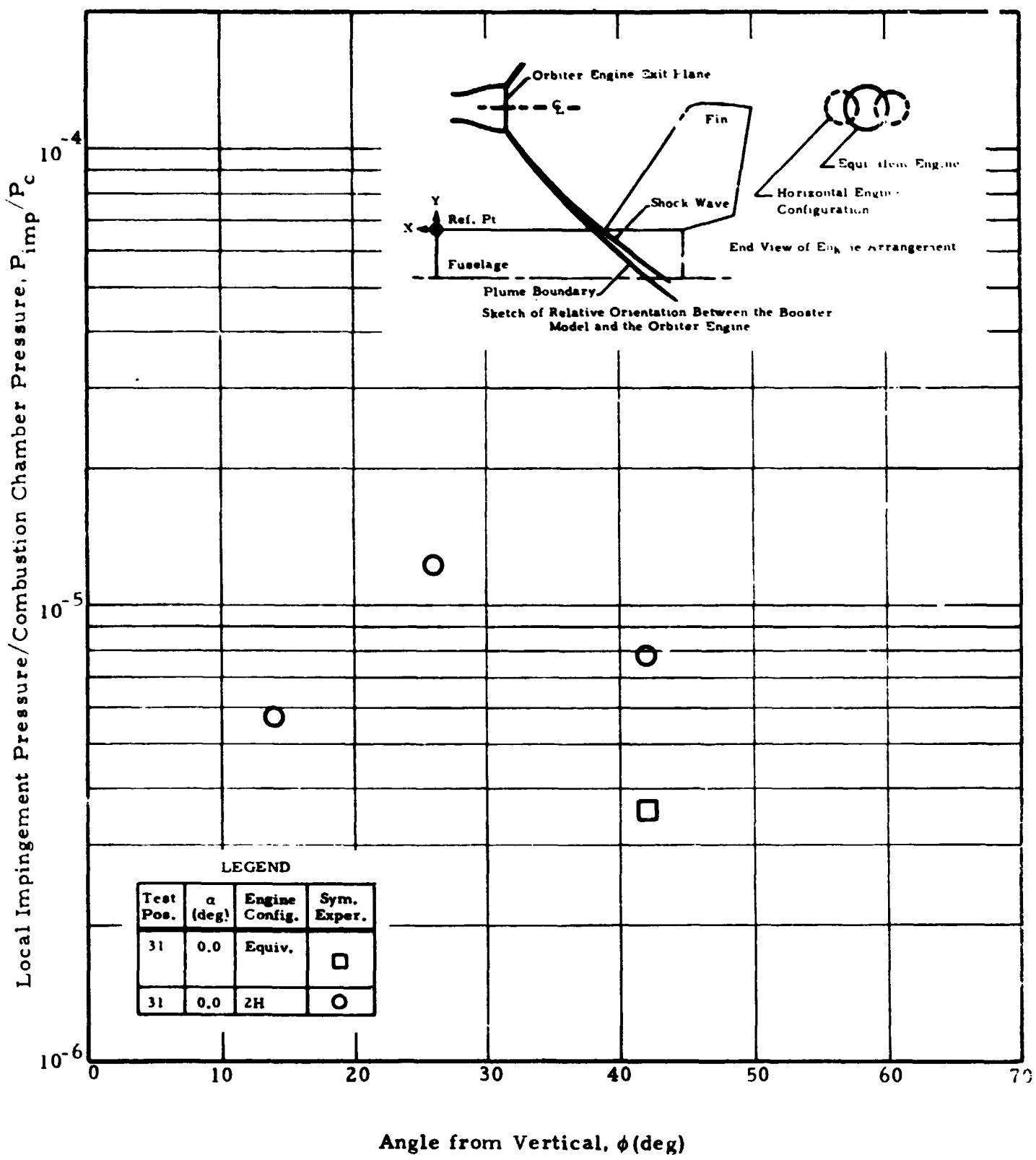


Fig. 88 - Impingement Pressure Distribution over the Booster Fuselage at Station 107.12 (Test Pos. 31)

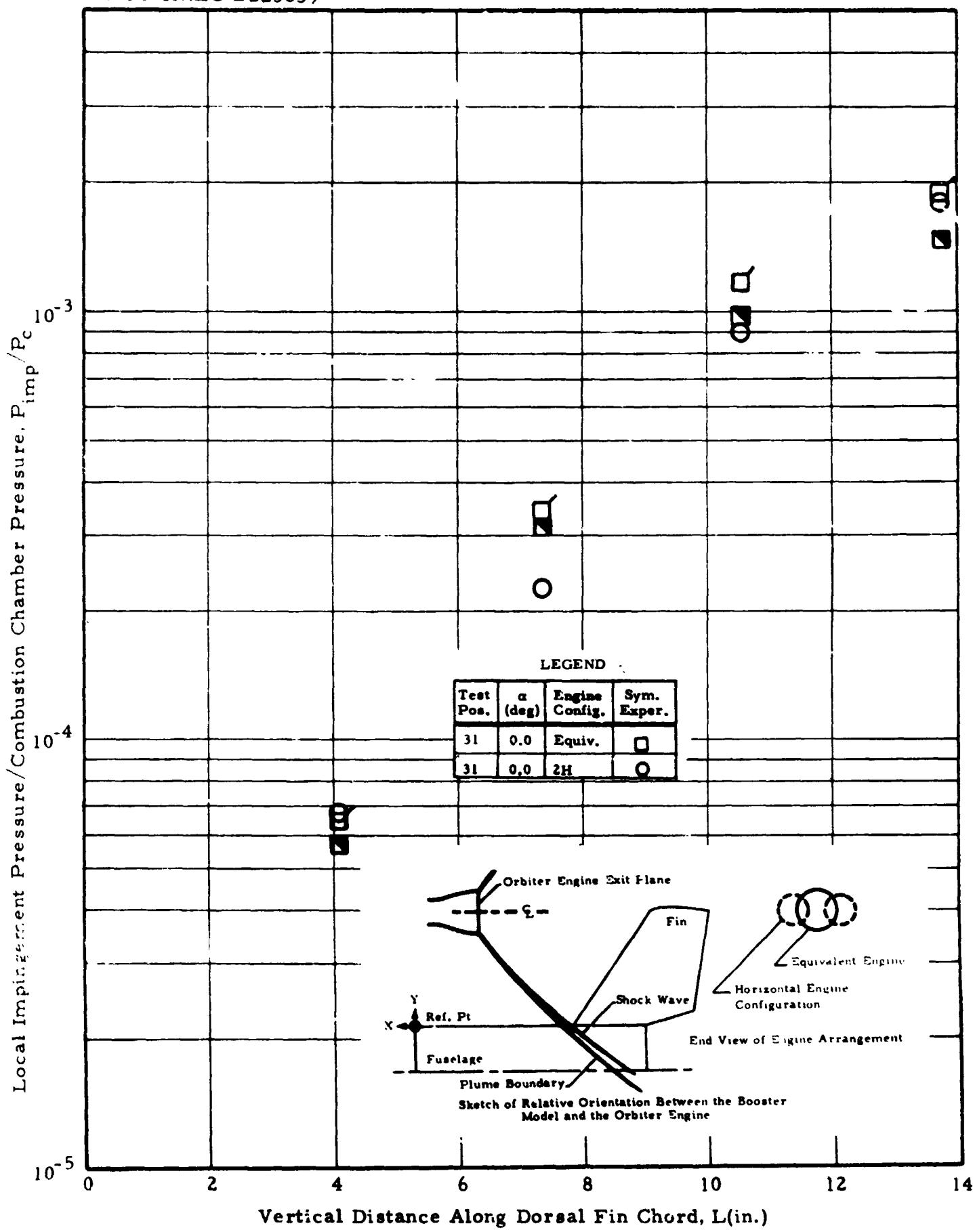


Fig. 89 - Impingement Pressure Distribution Along Dorsal Fin Leading Edge
(Test Pos. 31)

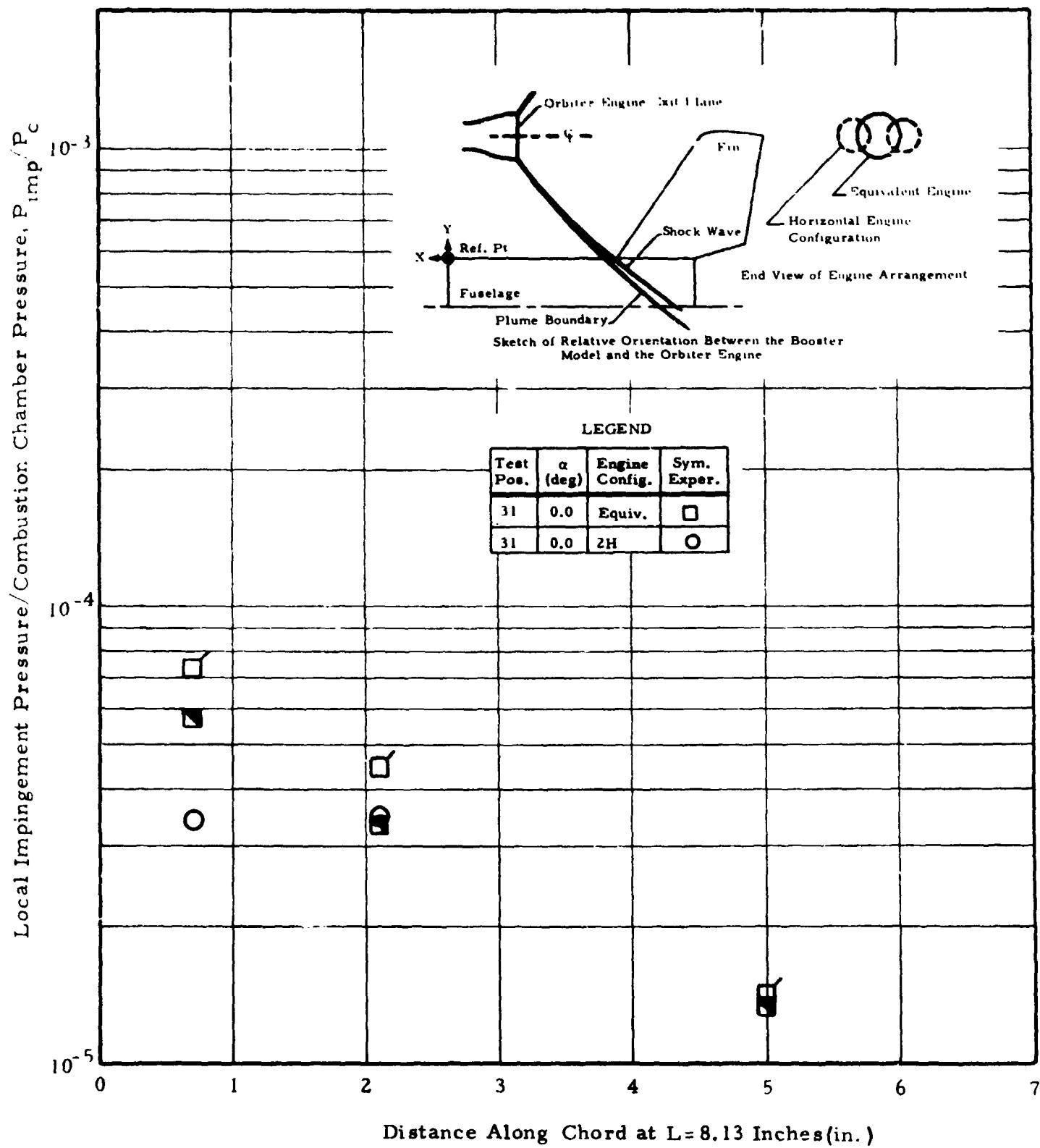
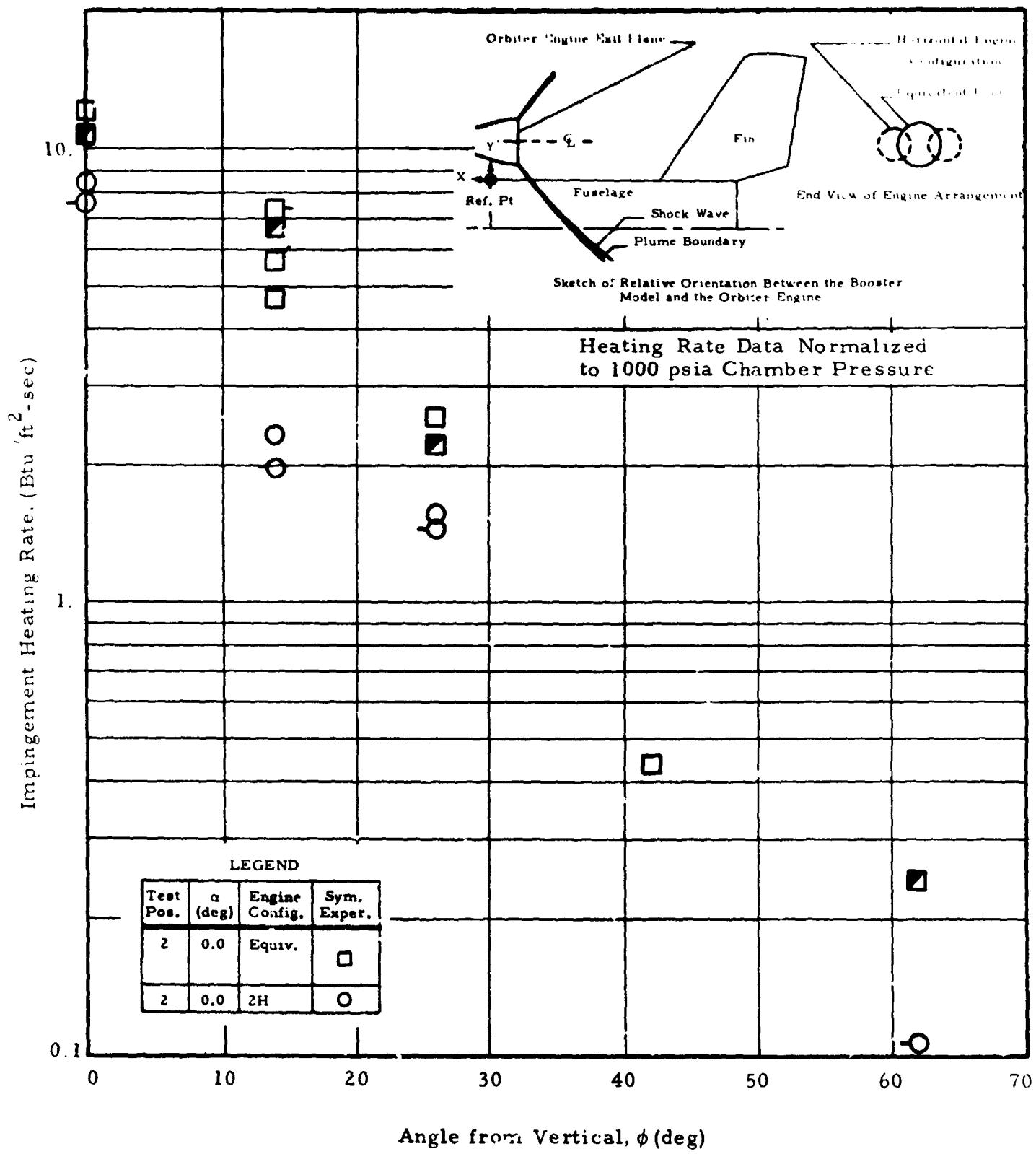


Fig. 90 - Impingement Pressure Distribution Along Dorsal Fin Chord
(Test Pos. 31)

Fig. 91 - Heat Transfer Distribution over Fuselage
at Station 85.62 (Test Pos. 2)

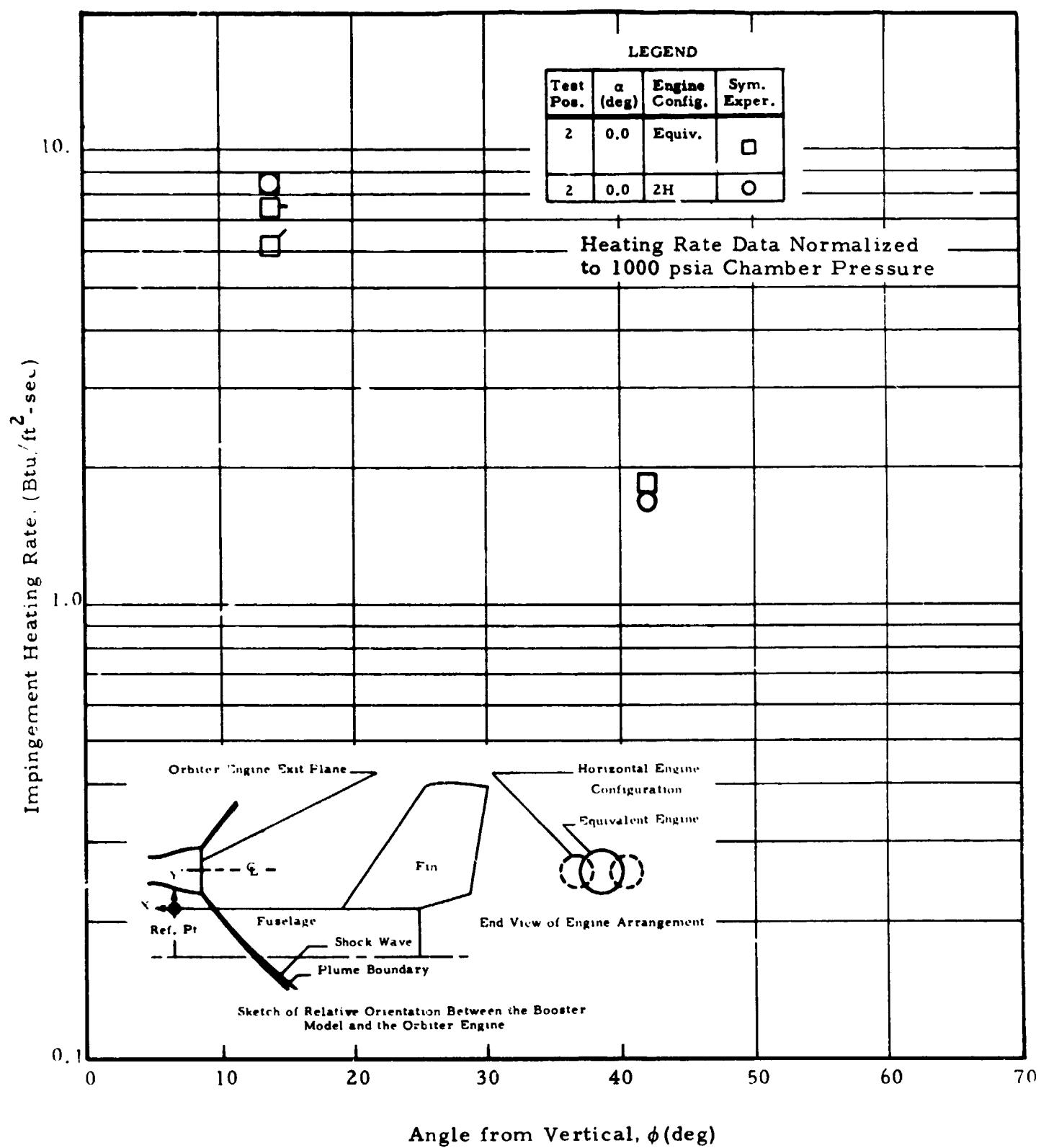


Fig. 92 - Heat Transfer Distribution over Fuselage
at Station 94.62 (Test Pos. 2)

LMSC-HREC D225839

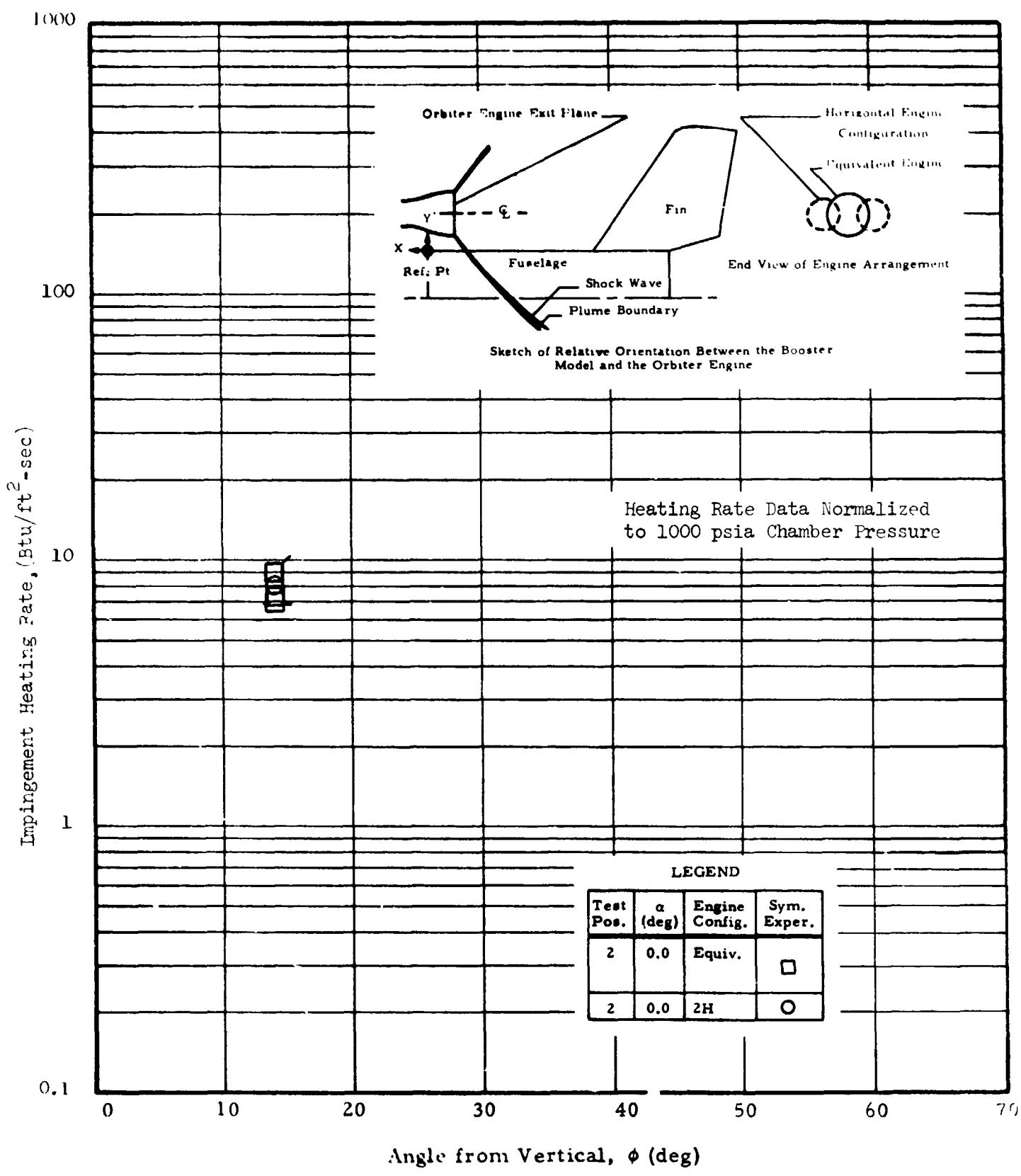


Fig. 93 - Heat Transfer Distribution over Fuselage
at Station 100.62 (Test Pos. 2)

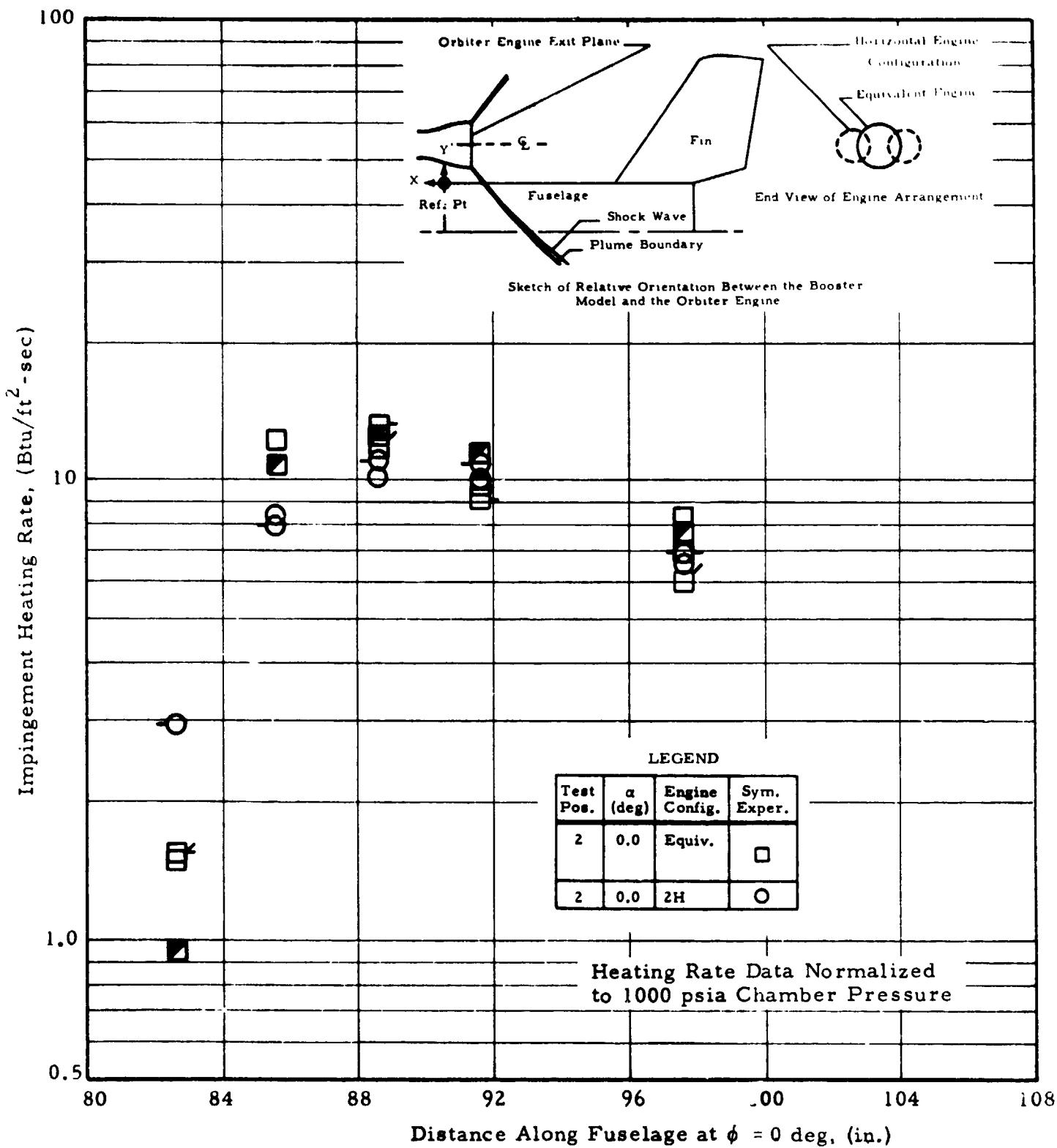


Fig. 94 - Heat Transfer Distribution Along Fuselage Stagnation Line (Test Pos. 2)

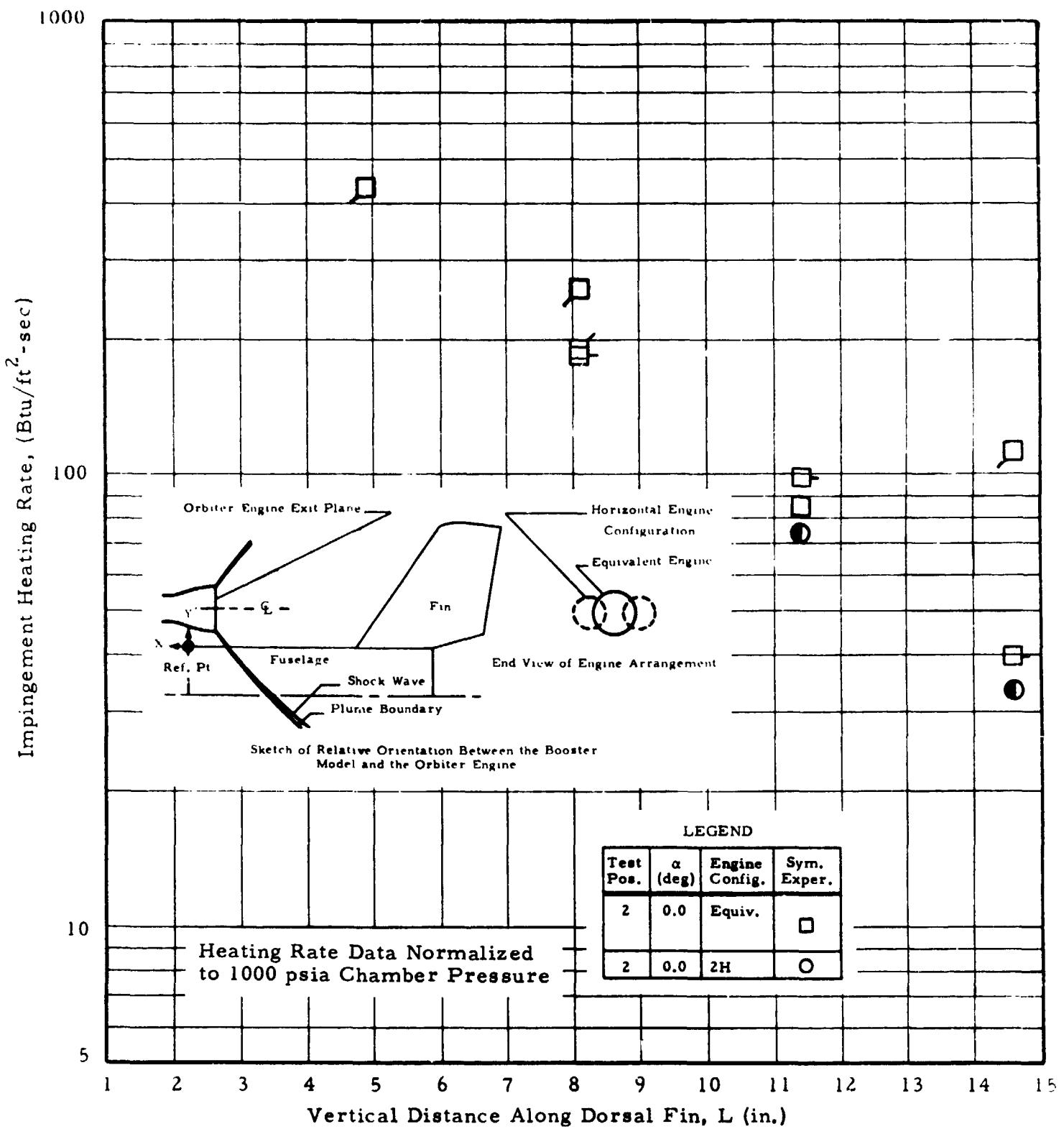


Fig. 95 - Heat Transfer Distribution Along Dorsal Fin Leading Edge (Test Pos. 2)

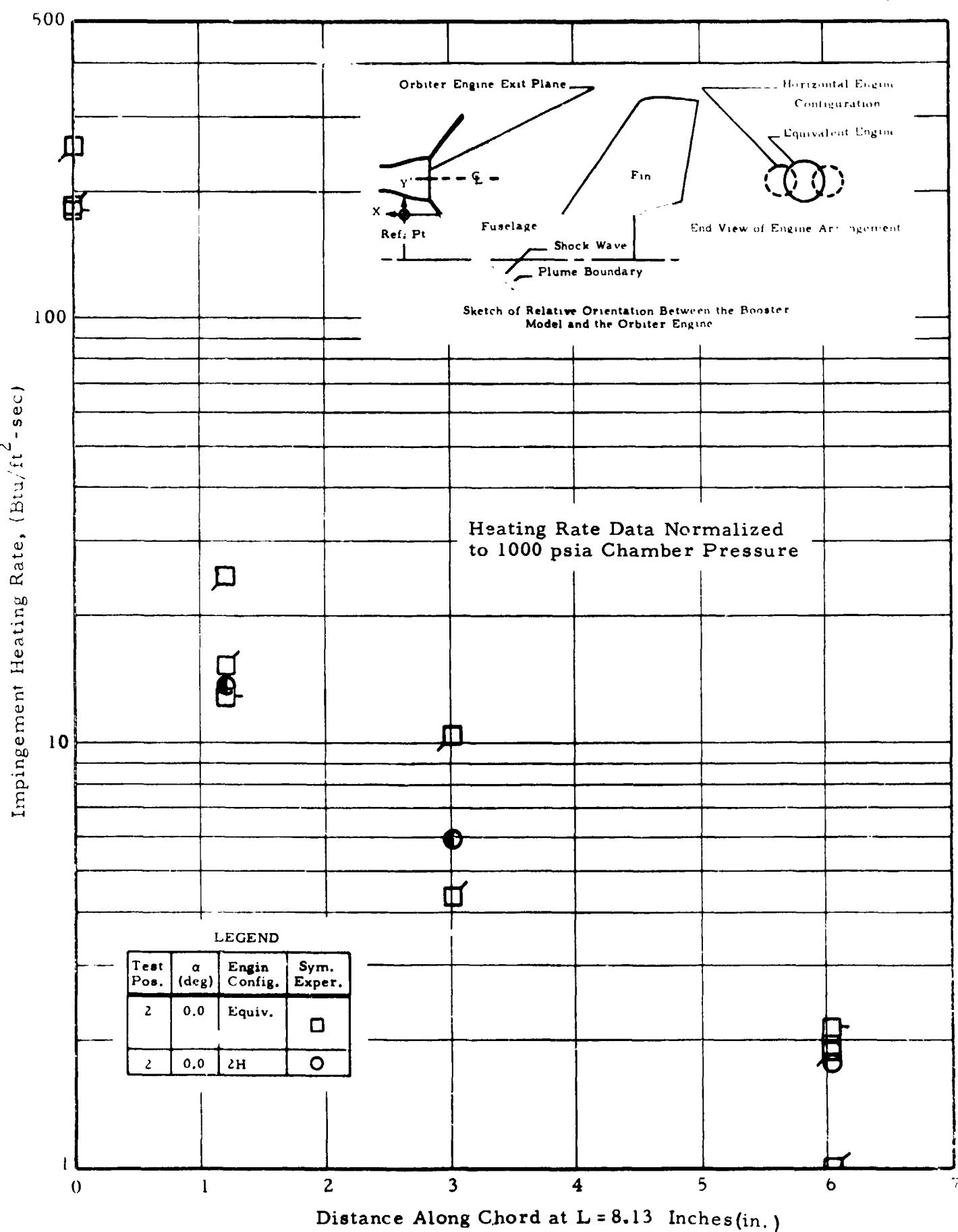


Fig. 96 - Heat Transfer Distribution Along Dorsal Fin Chord (Test Pos. 2)

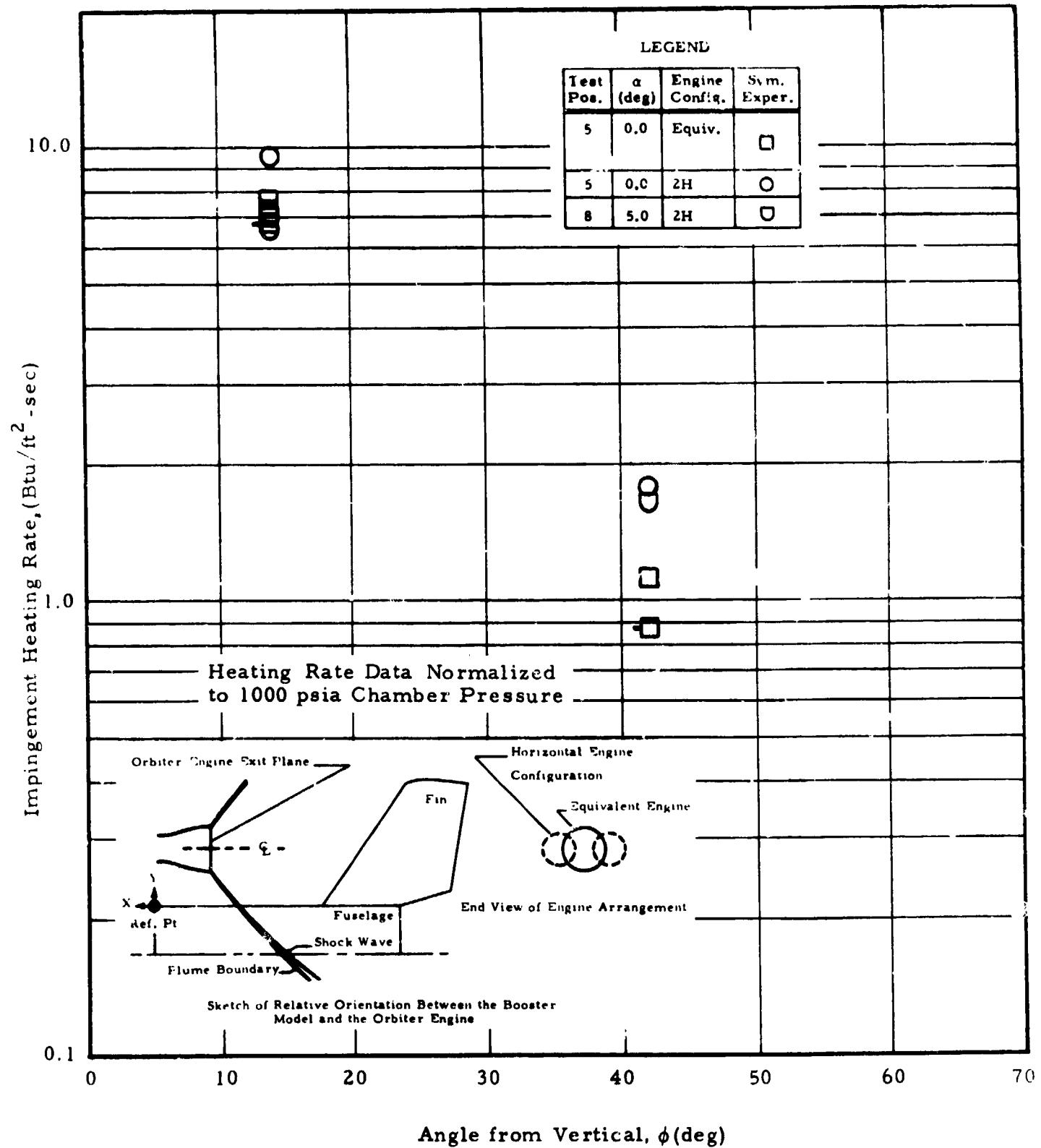


Fig. 97 - Heat Transfer Distribution over Fuselage at Station 94.62 (Test Pos. 5 and 8)

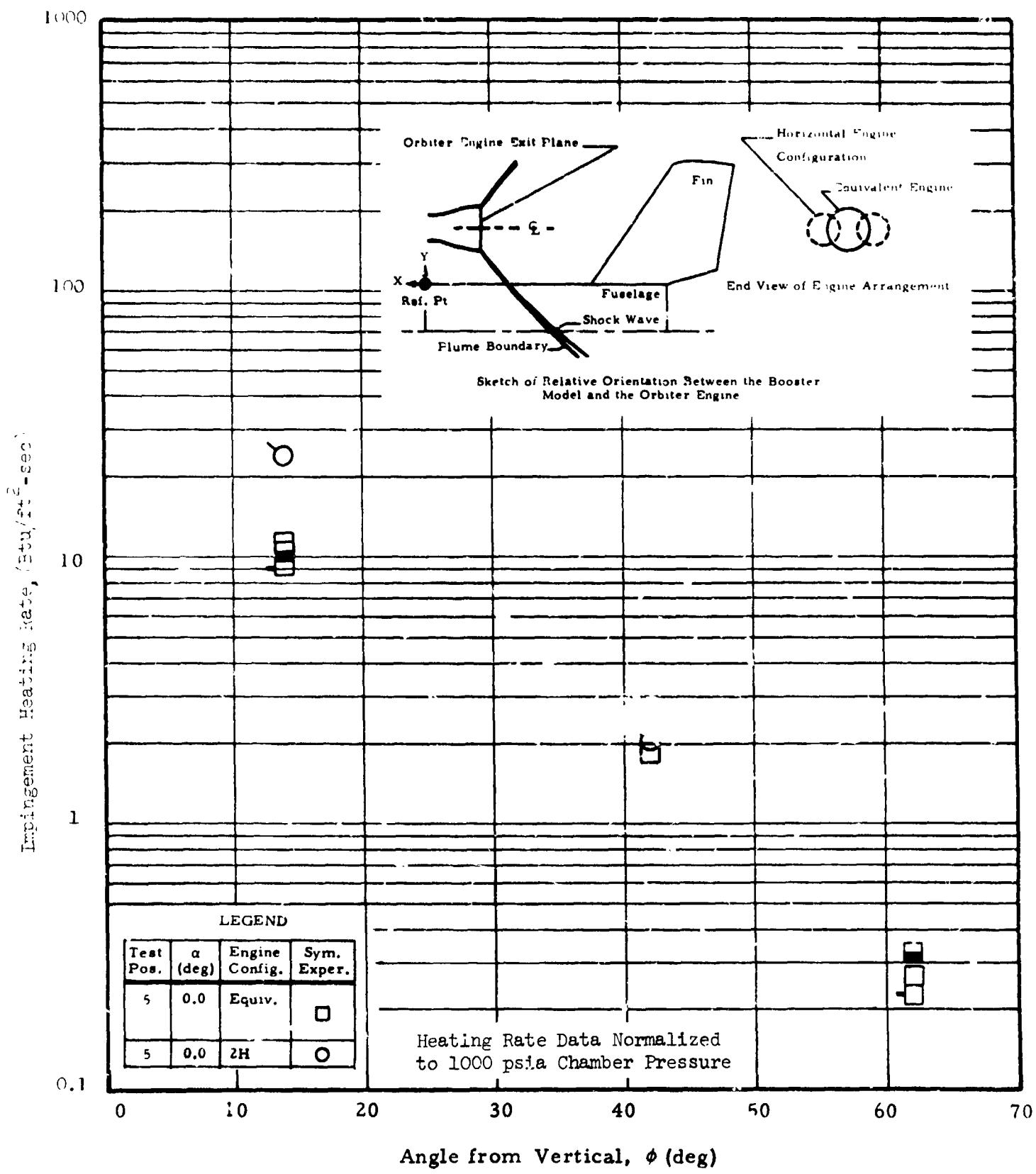


Fig. 98 - Heat Transfer Distribution over Fusel...
at Station 100.62 (Test Pos. 5)

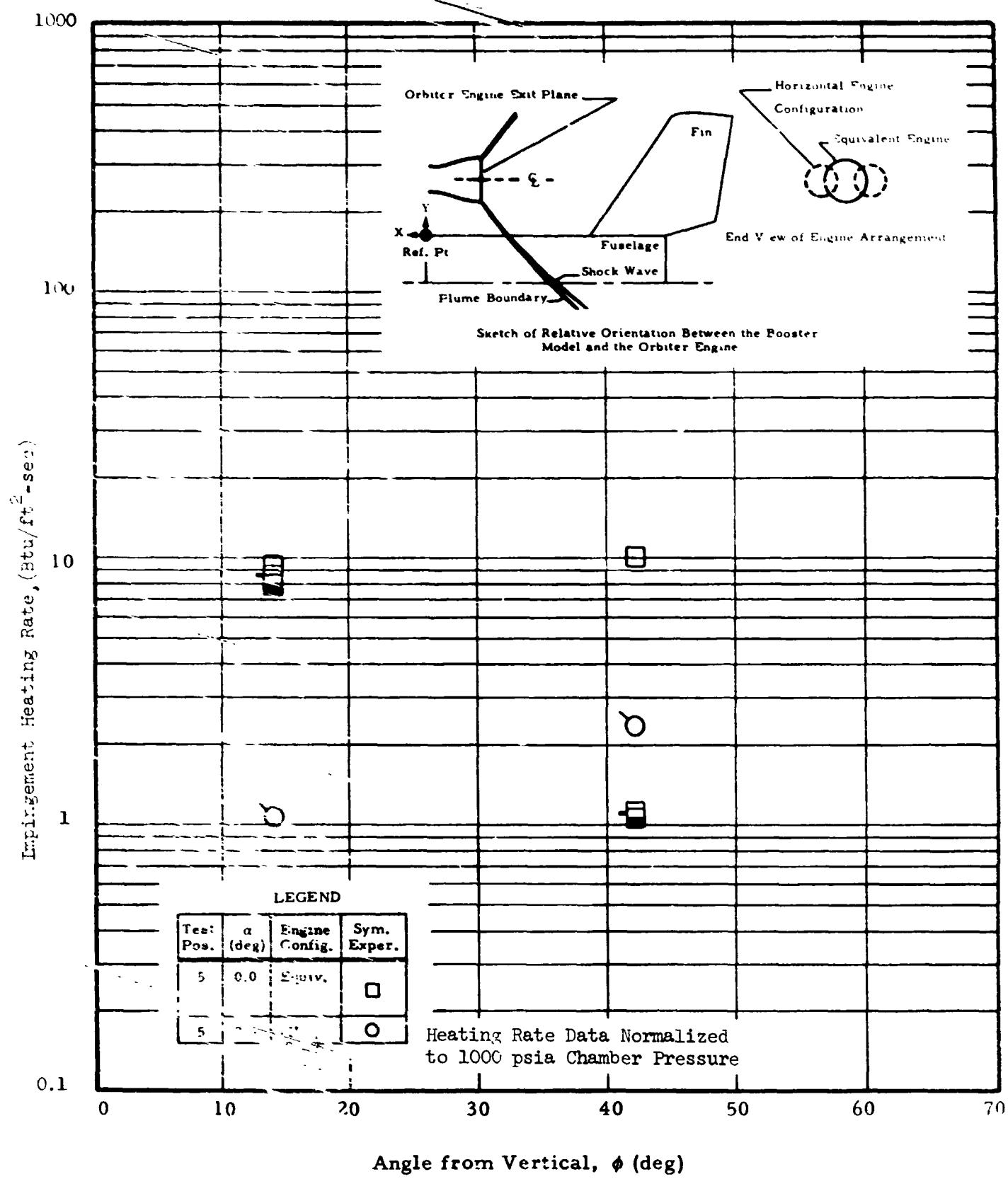


Fig. 22 - Heat Transfer Distribution over Fuselage
at Station 103.62 (Test Pos. 5)

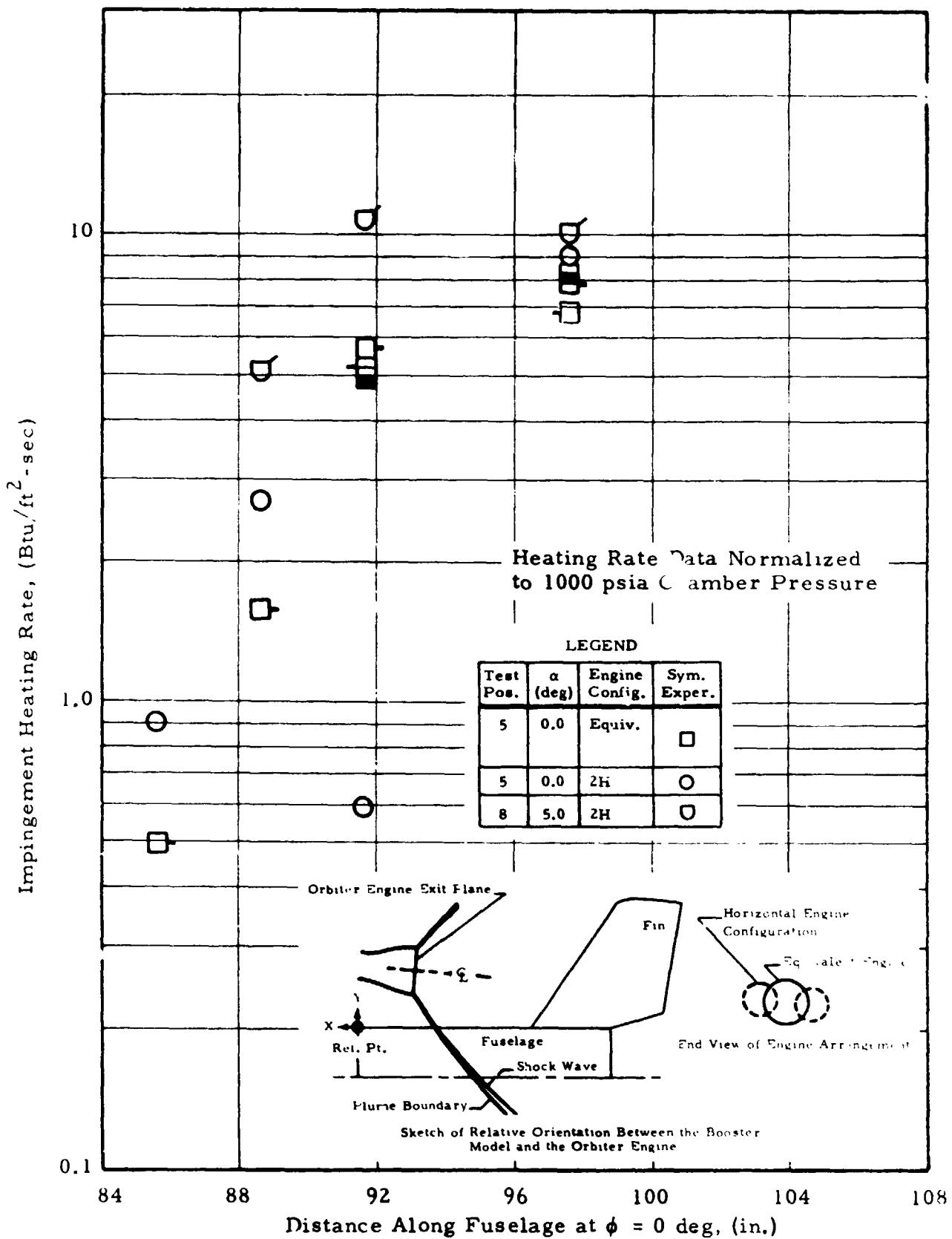


Fig. 100 - Heat Transfer Distribution Along Fuselage Stagnation Line
(Test Positions 5 and 8)

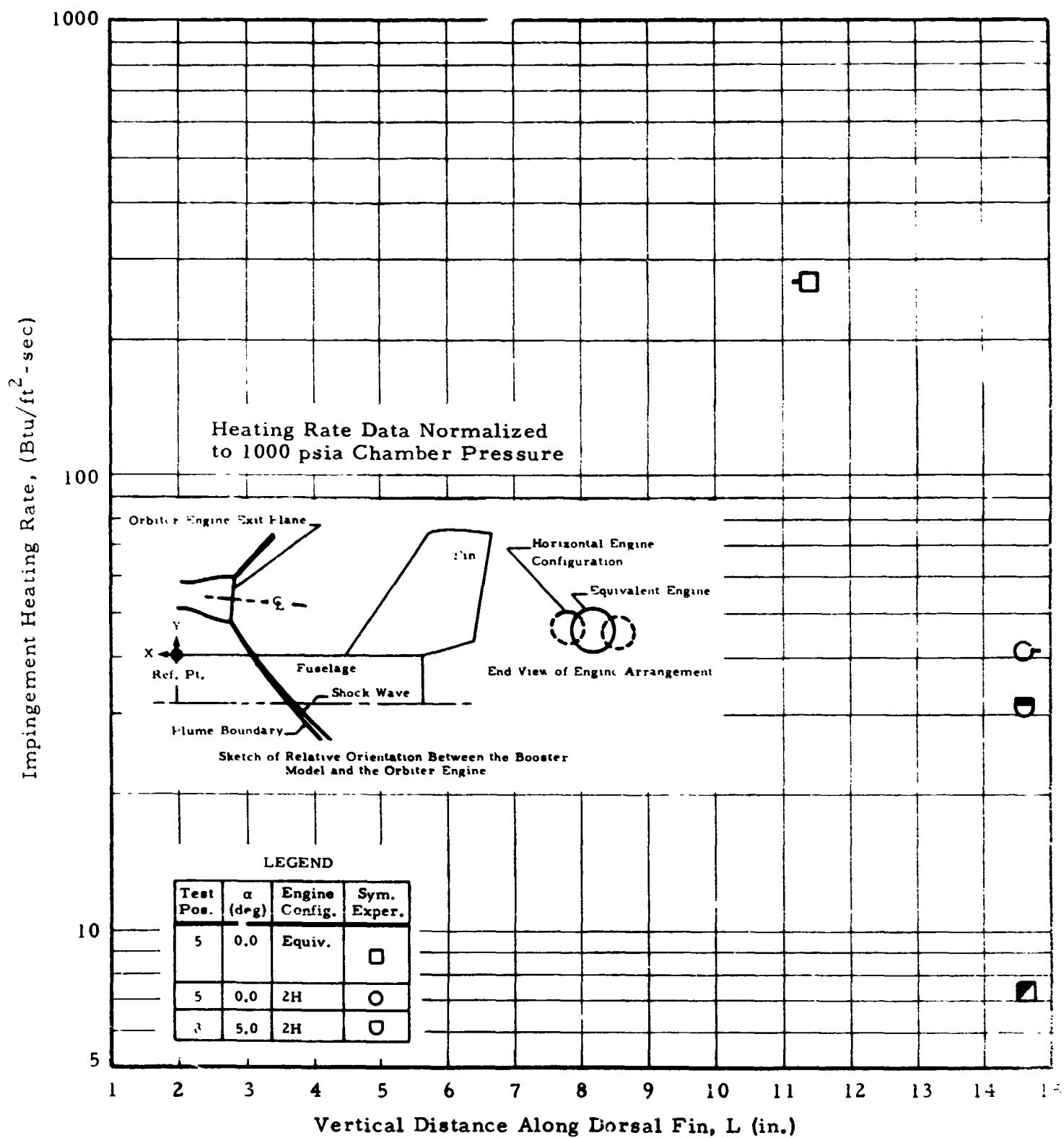


Fig. 101 - Heat Transfer Distribution Along Dorsal Fin Leading Edge
(Test Positions 5 and 8)

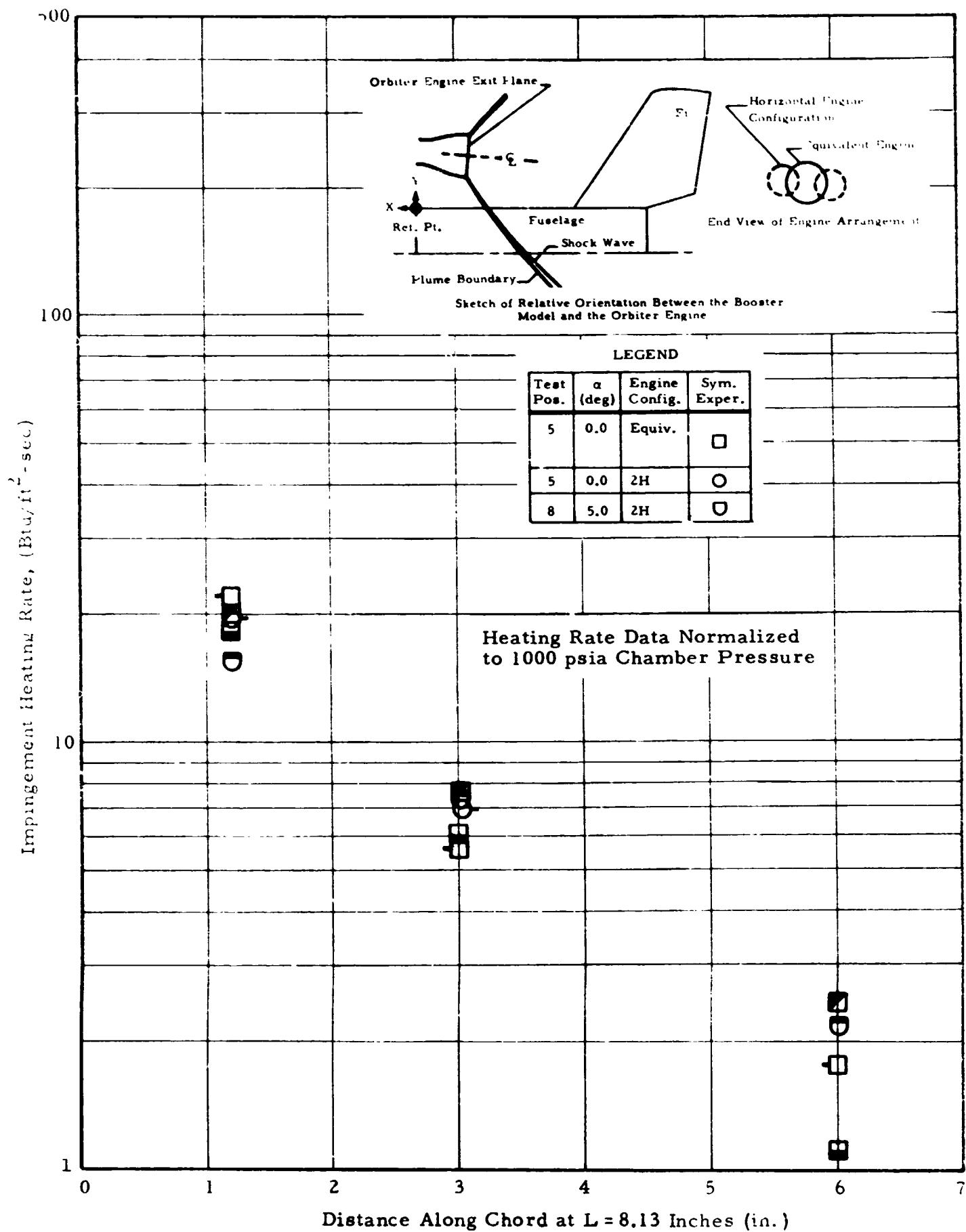
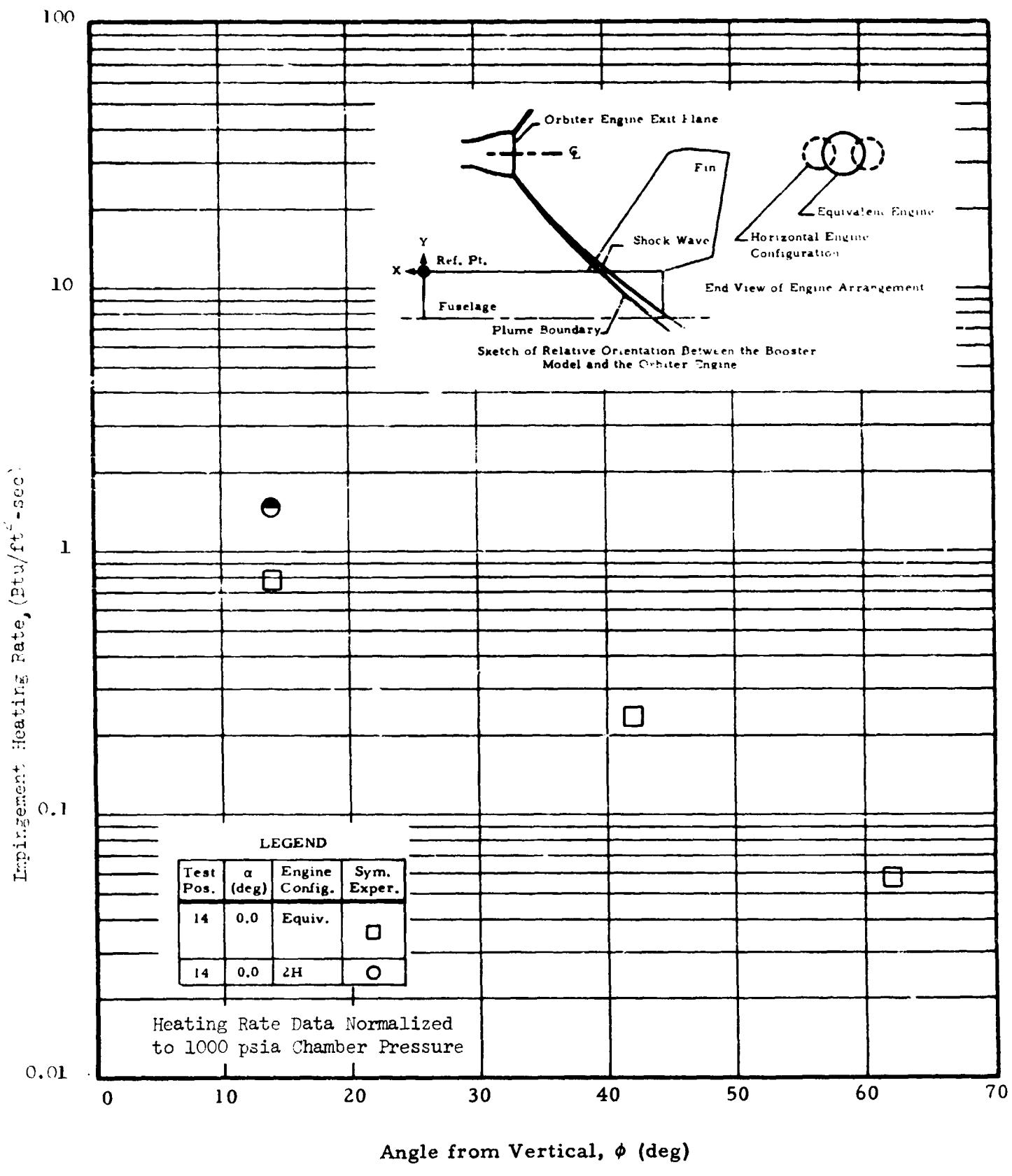


Fig. 102 - Heat Transfer Distribution Along Dorsal Fin Chord (Test Pcs. 5 and 8)

Fig. 103 - Heat Transfer Distribution over Fuselage
at Station 100.62 (Test Pos. 14)

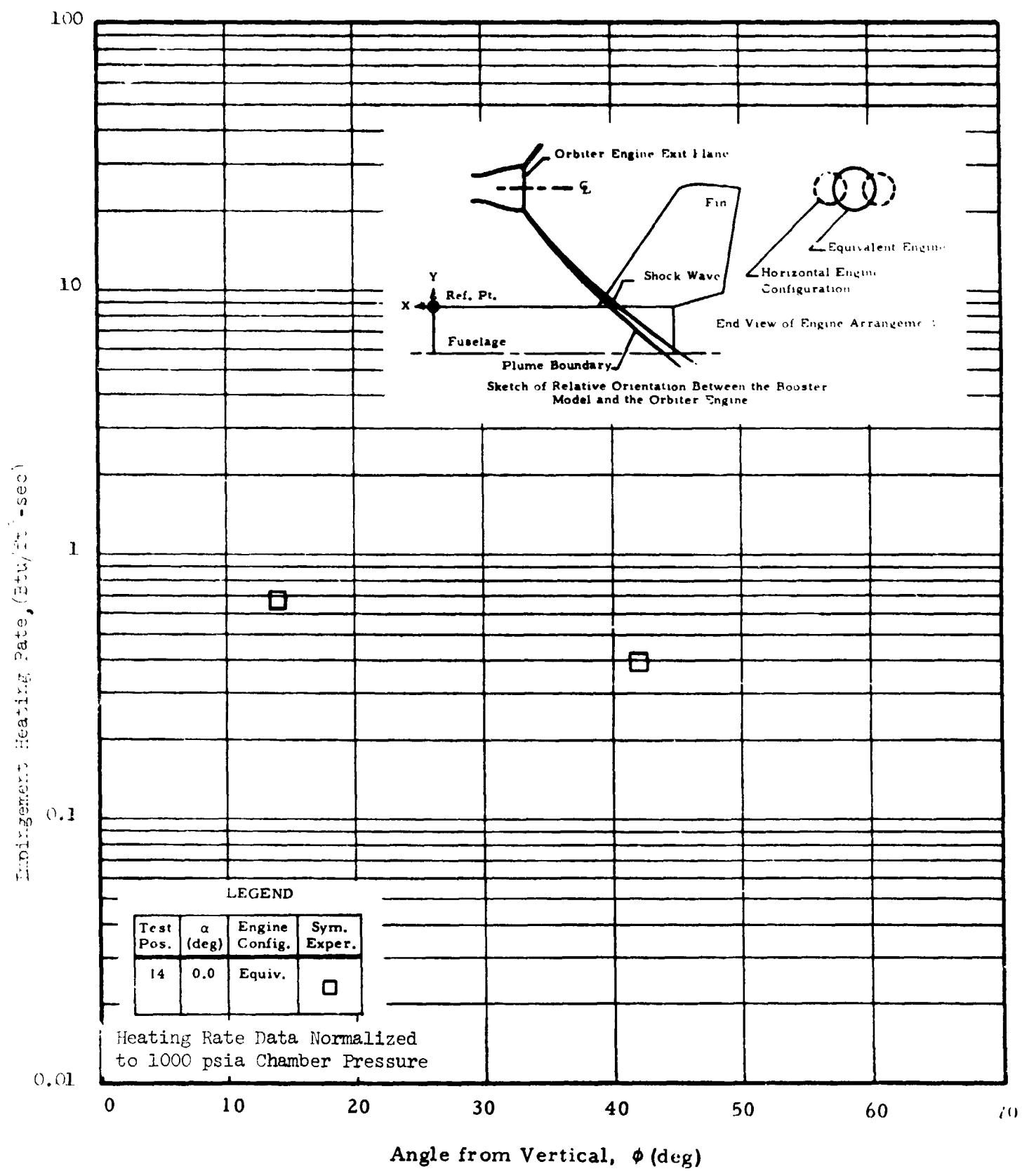


Fig. 104 - Heat Transfer Distribution over Fuselage
at Station 103.62 (Test Pos. 14)

LMSC-HREC D225839

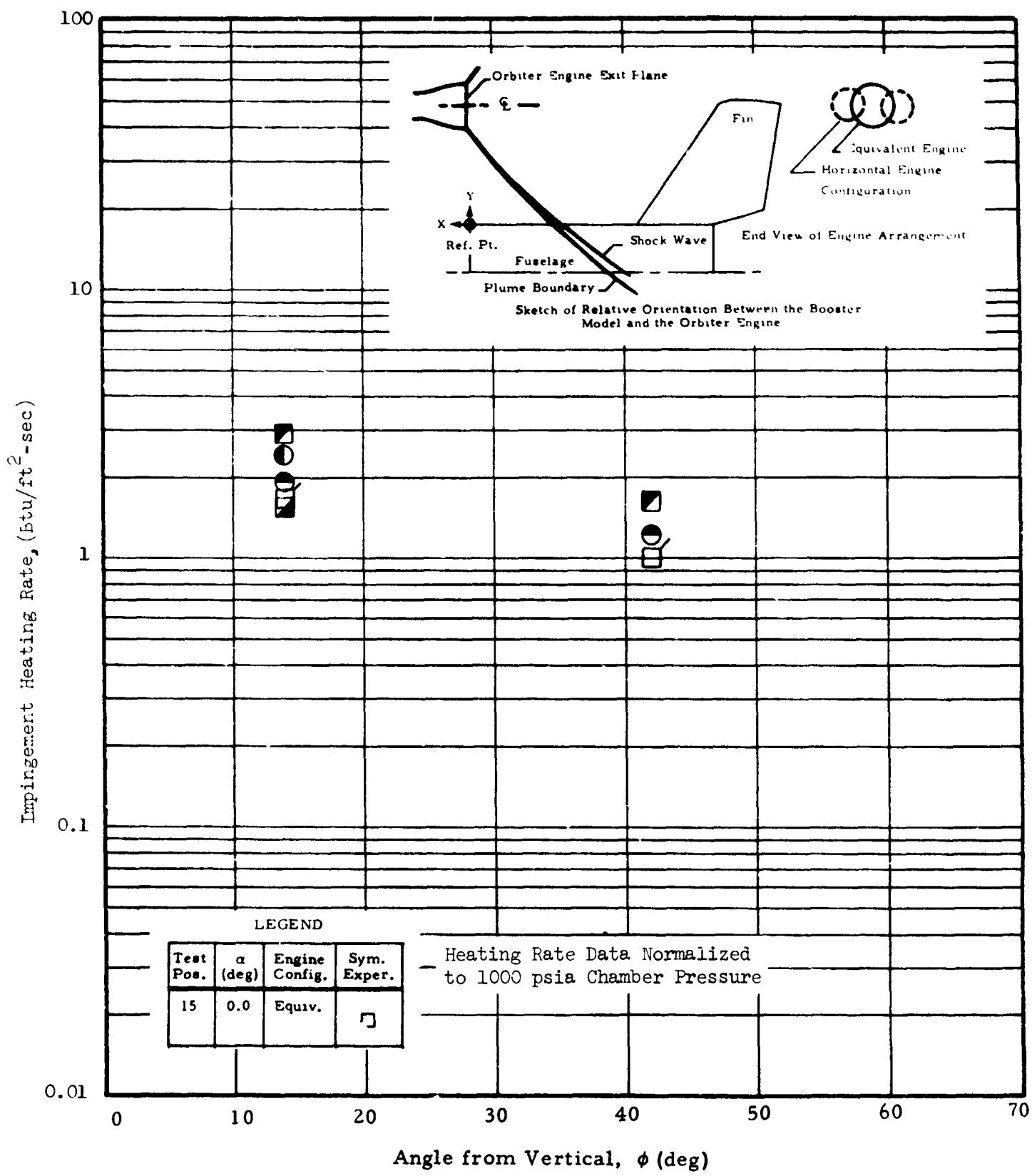


Fig. 105 - Heat Transfer Distribution over Fuselage
at Station 103.62 (Test Pos. 15)

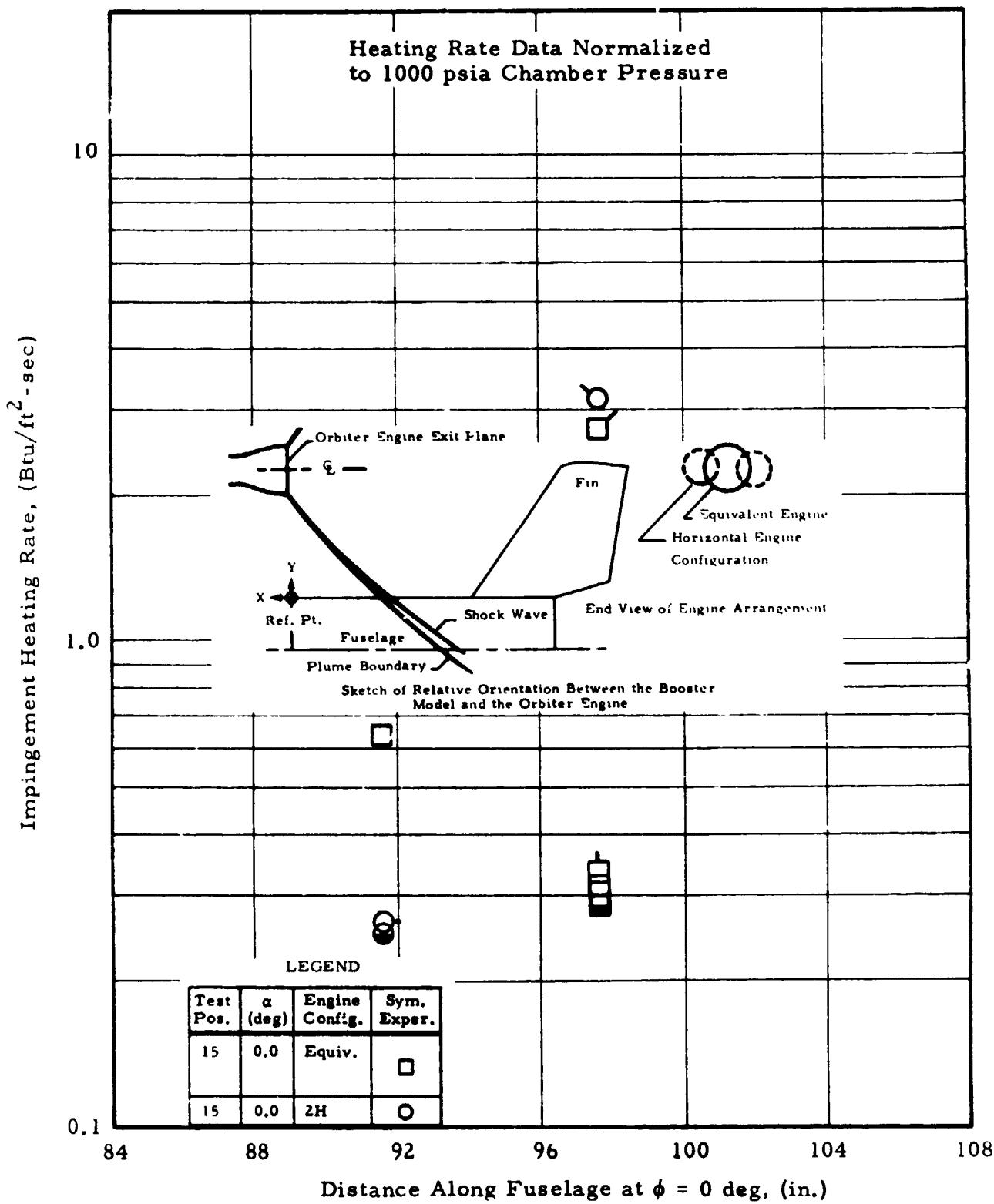


Fig. 106 - Heat Transfer Distribution Along Fuselage Stagnation Line (Test Pos. 15)

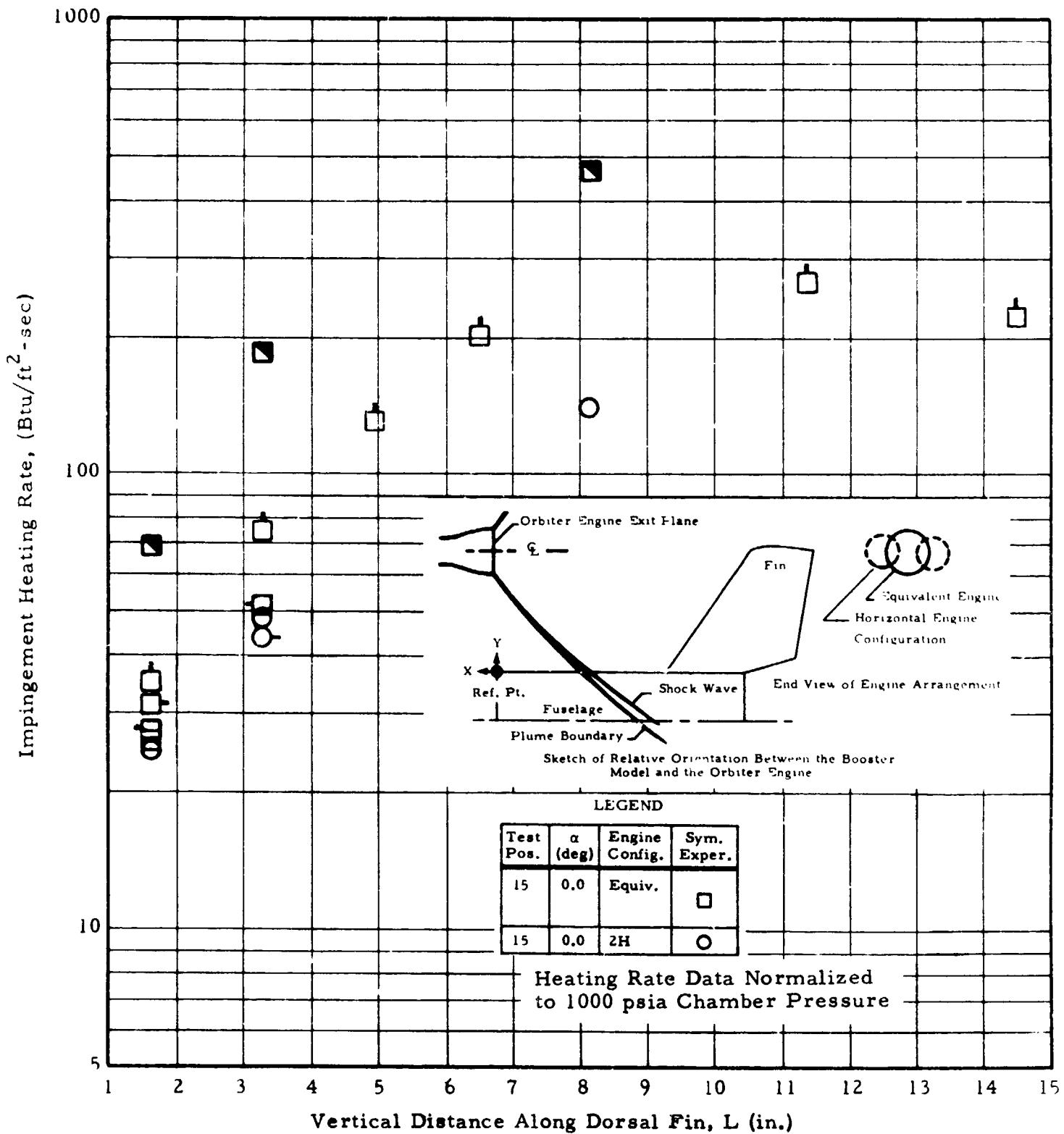


Fig 107 - Heat Transfer Distribution Along Dorsal Fin Leading Edge (Test Pos. 15)

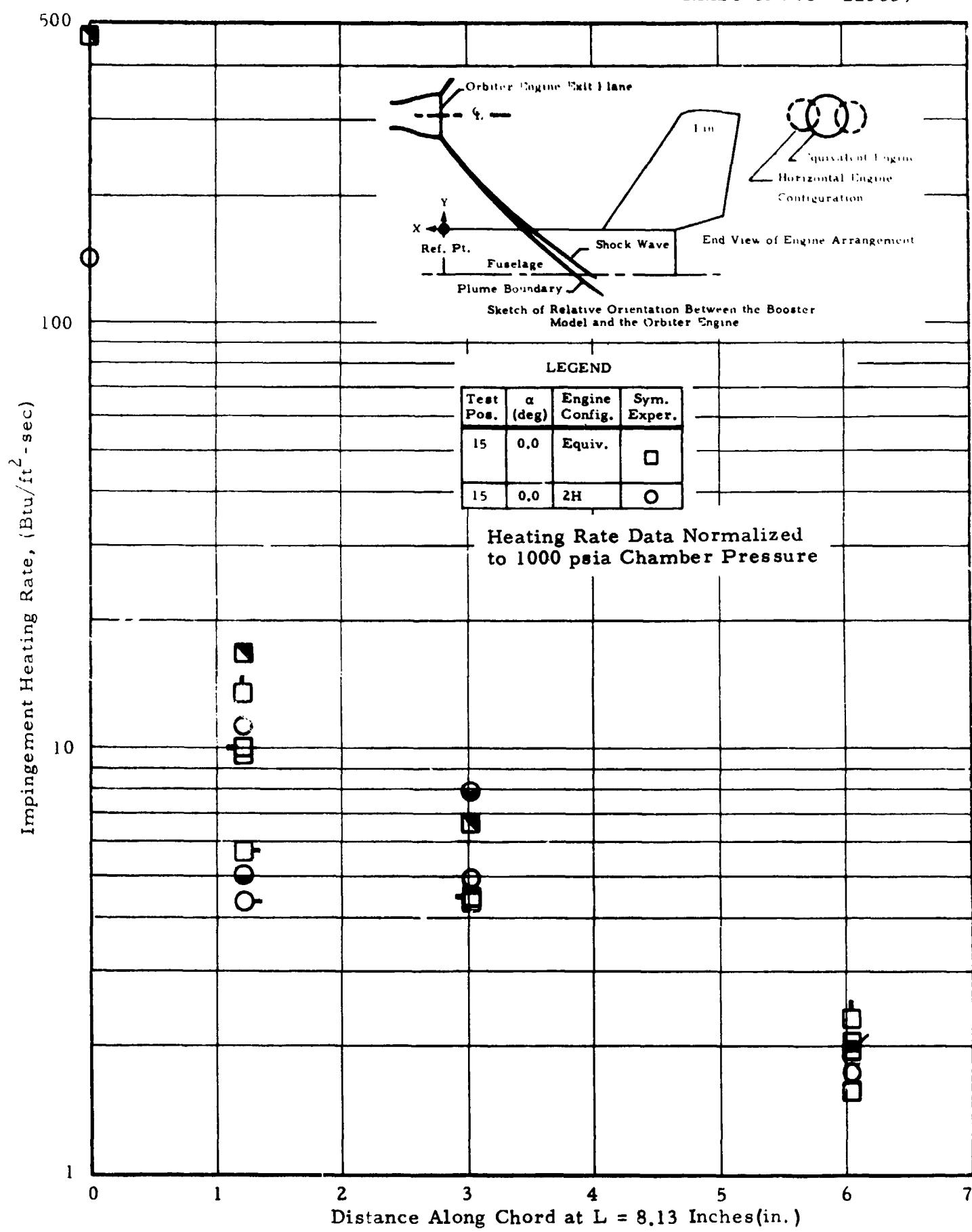


Fig. 108 - Heat Transfer Distribution Along Dorsal Fin Chord (Test Pos. 15)

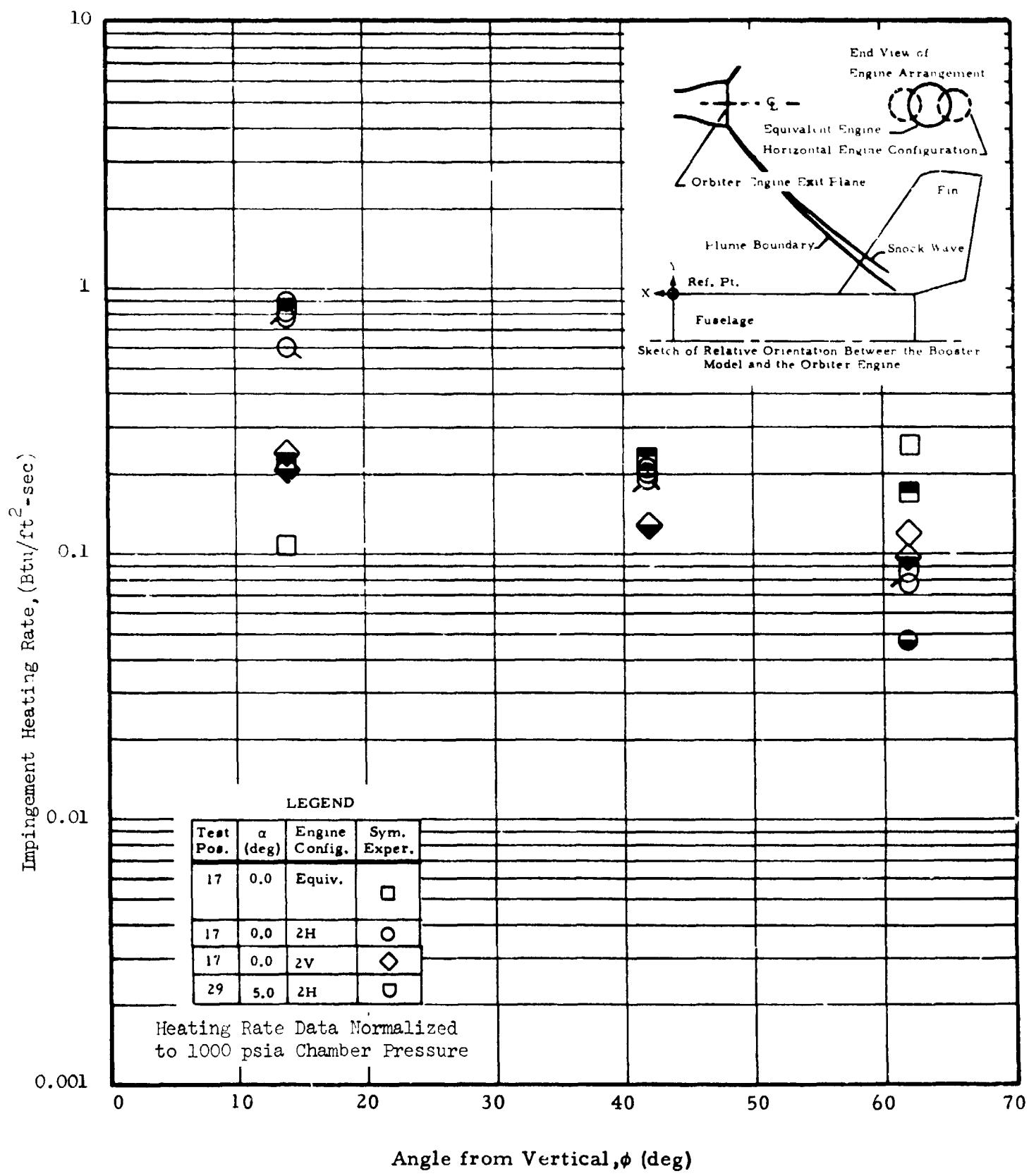


Fig. 109 - Heat Transfer Distribution over Fuselage at Station 100.62 (Test Pos. 17 and 29)

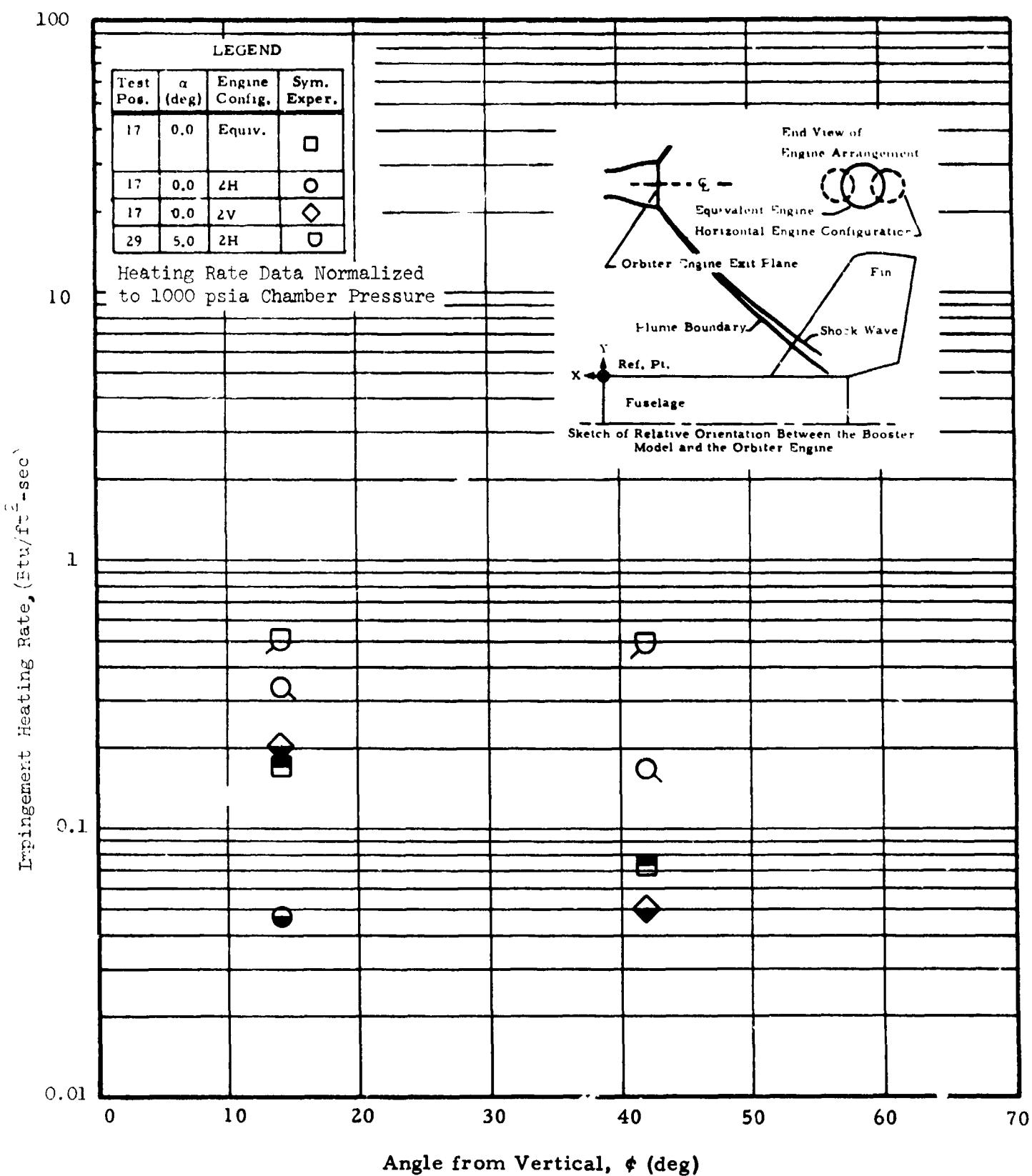


Fig. 110 - Heat Transfer Distribution over Fuselage at Station 103.62 (Test Pos. 17 and 29)

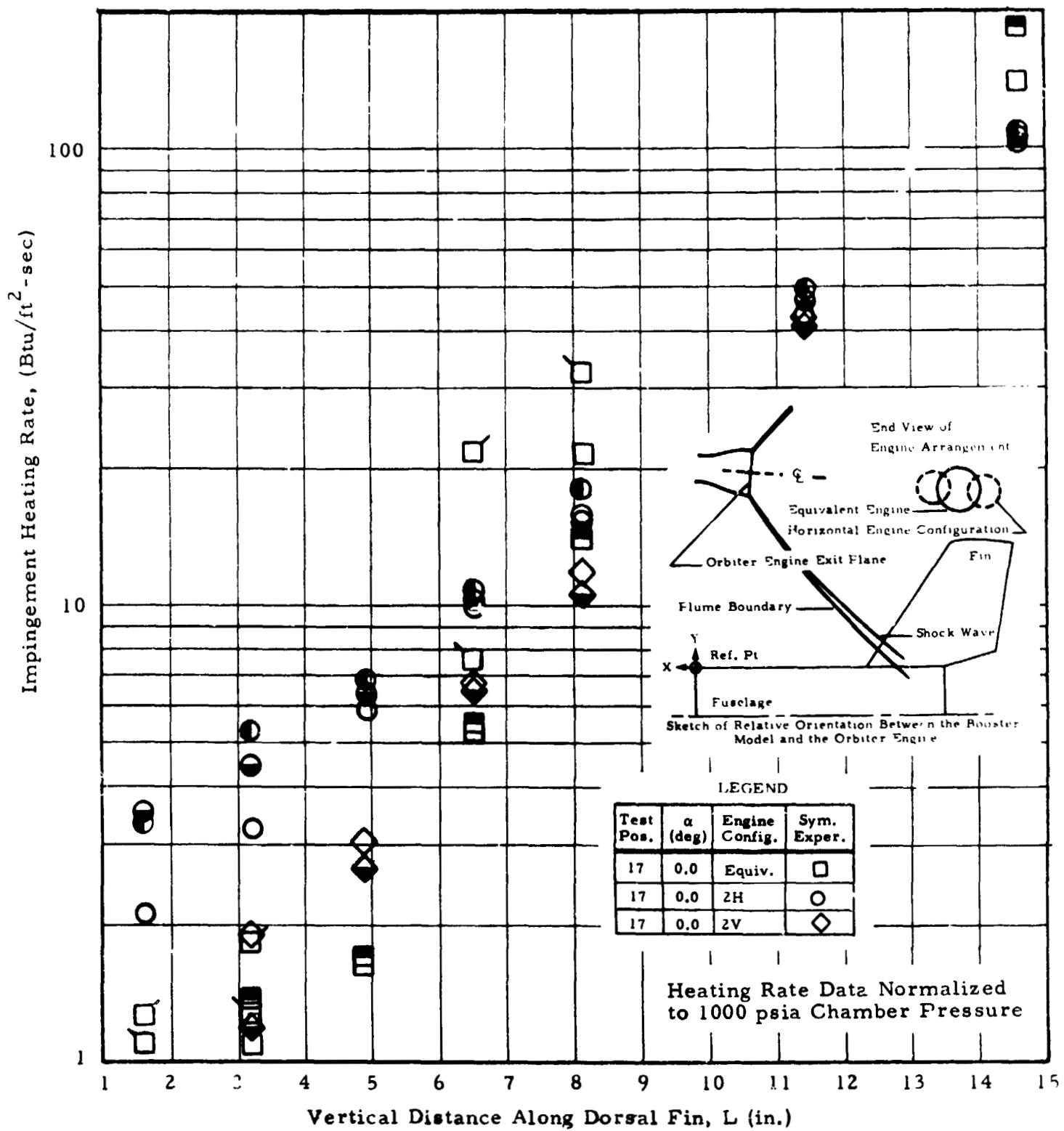


Fig. 111 - Heat Transfer Distribution Along Dorsal Fin Leading Edge (Test Pos. 17)

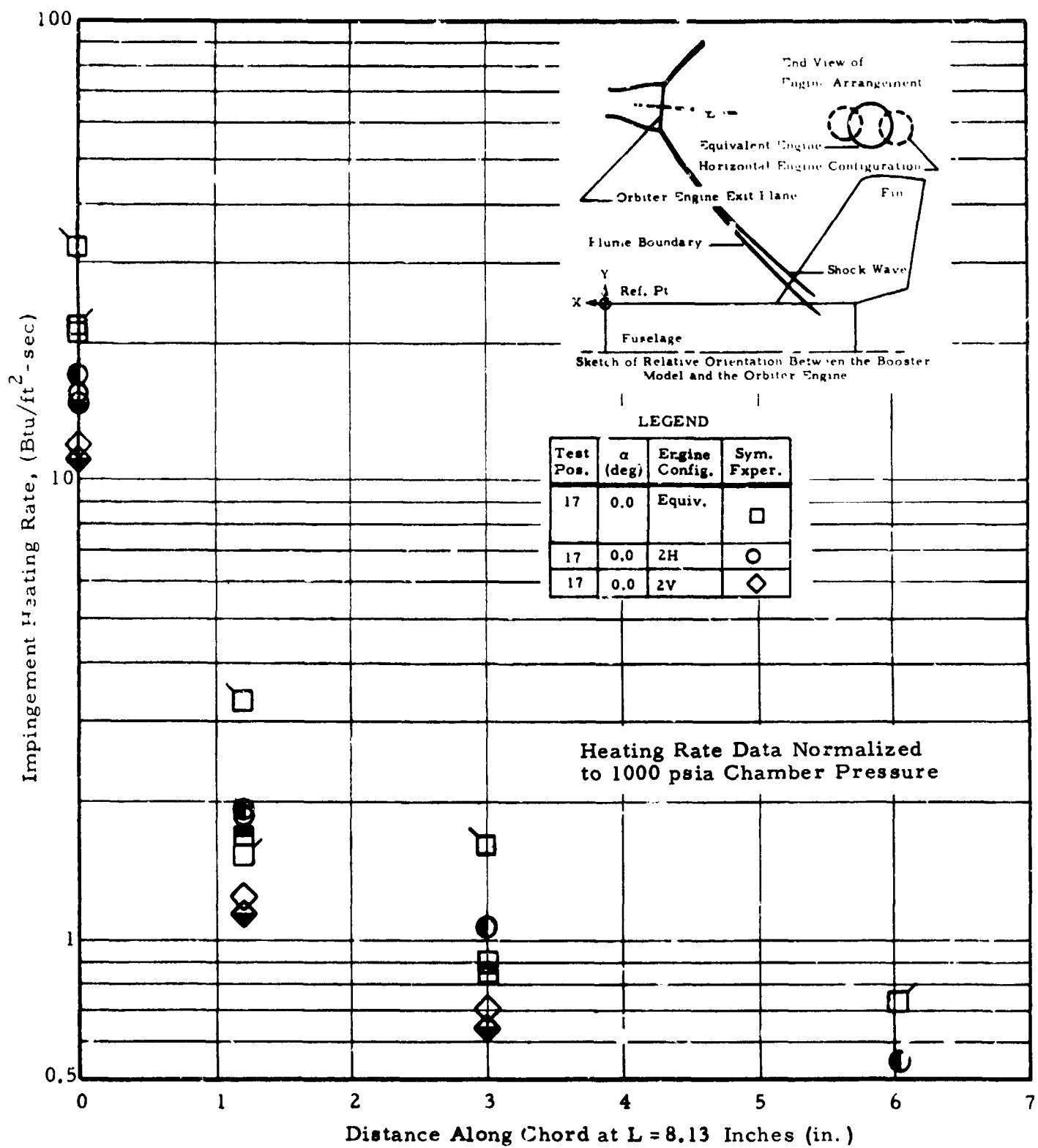


Fig. 112 - Heat Transfer Distribution Along Dorsal Fin Chord (Test Pos. 17)

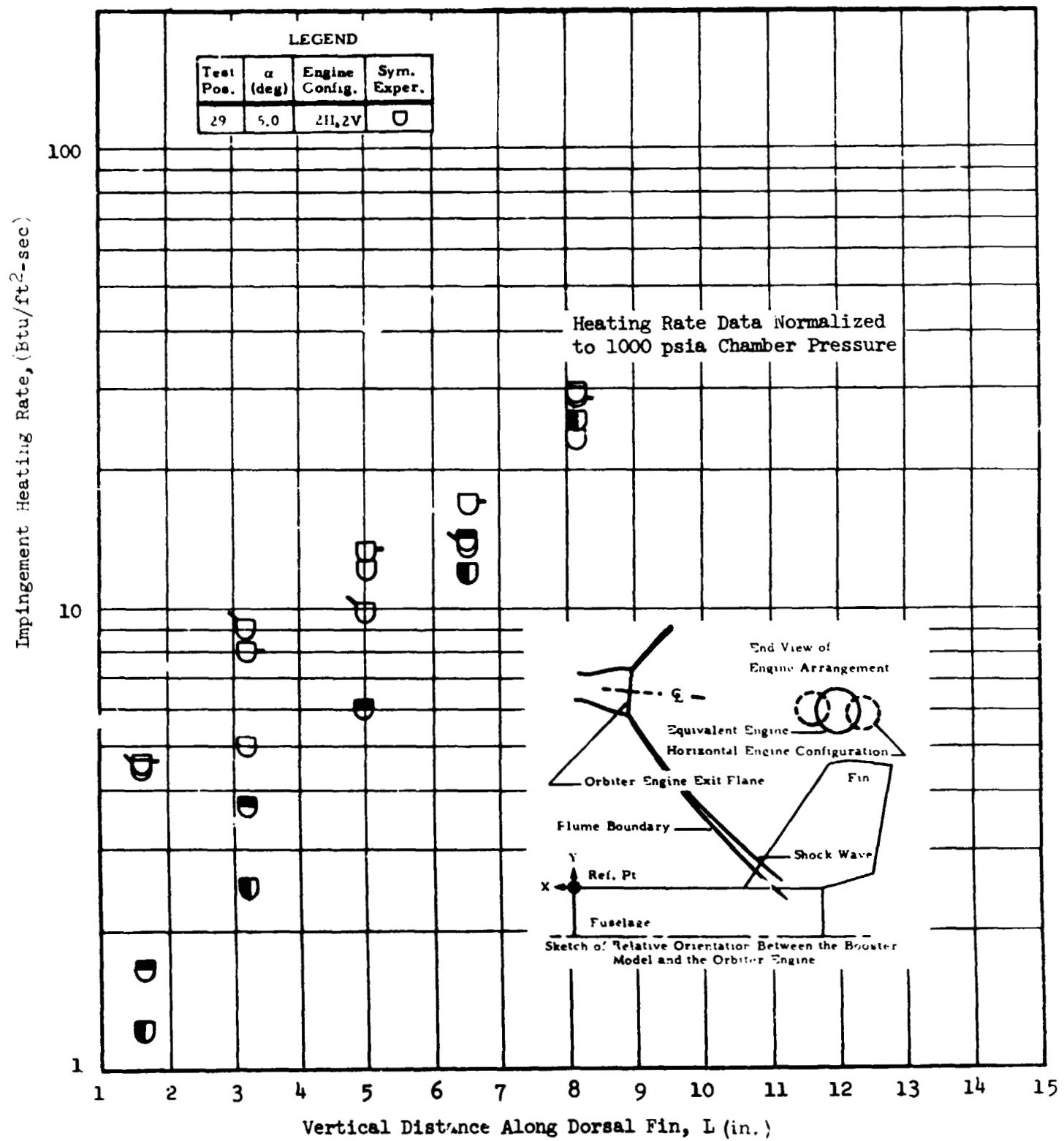


Fig. 113 - Heat Transfer Distribution Along Dorsal Fin Leading Edge (Test Pos. 29)

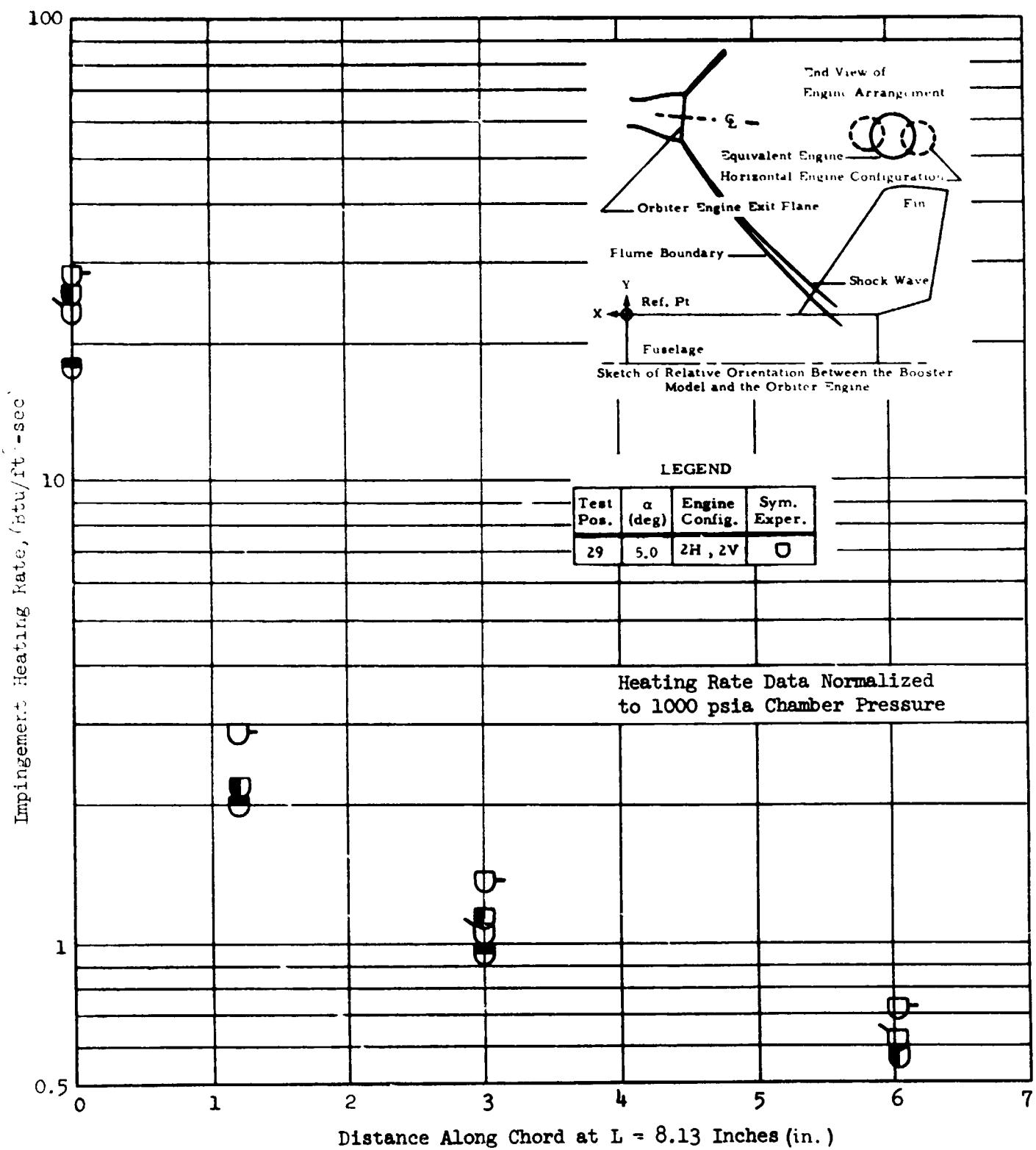


Fig. 114 - Heat Transfer Distribution Along Dorsal Fin Chord (Test Pos. 29)

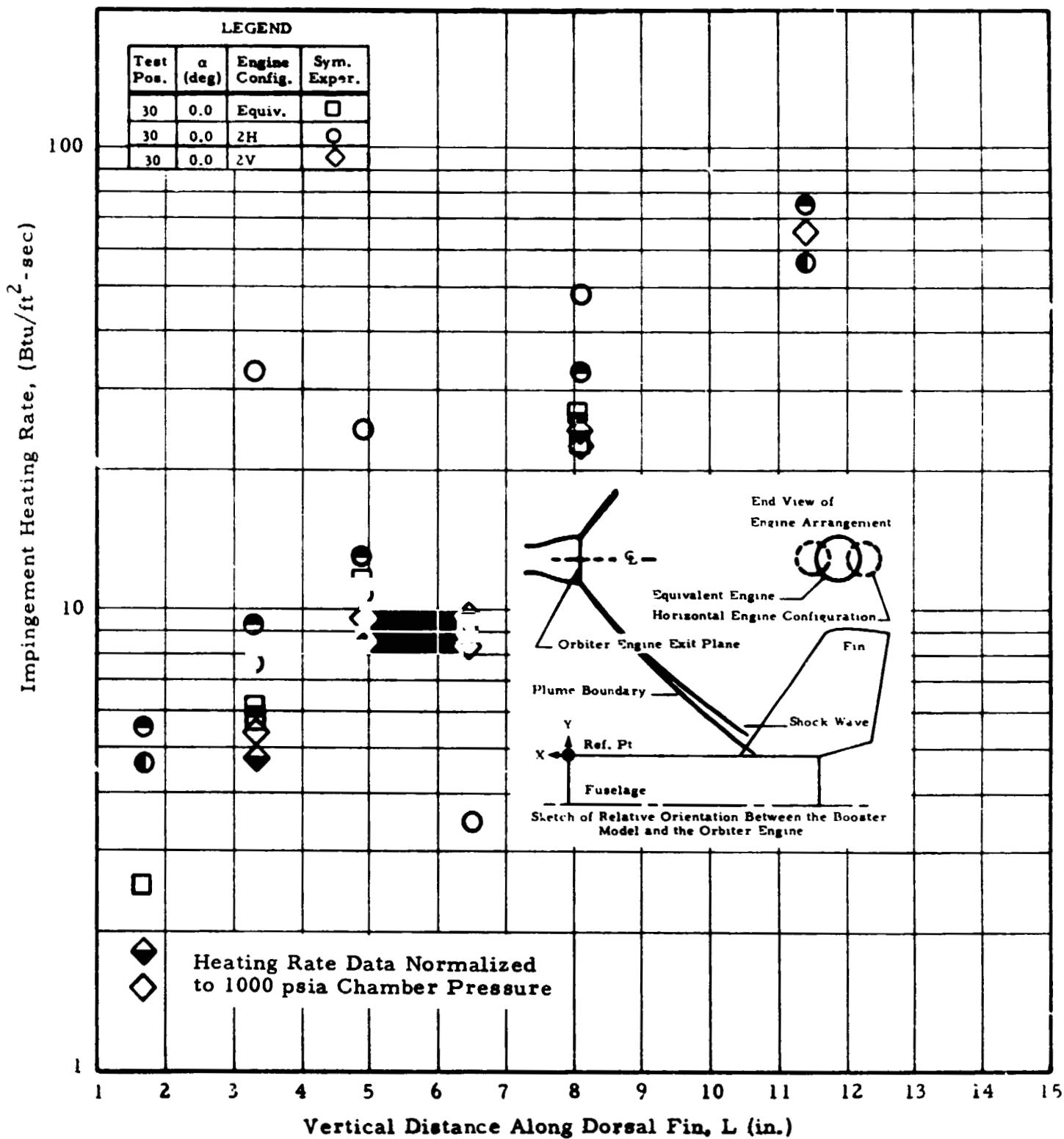


Fig. 115 - Heat Transfer Distribution Along Dorsal Fin Leading Edge (Test Pos. 30)

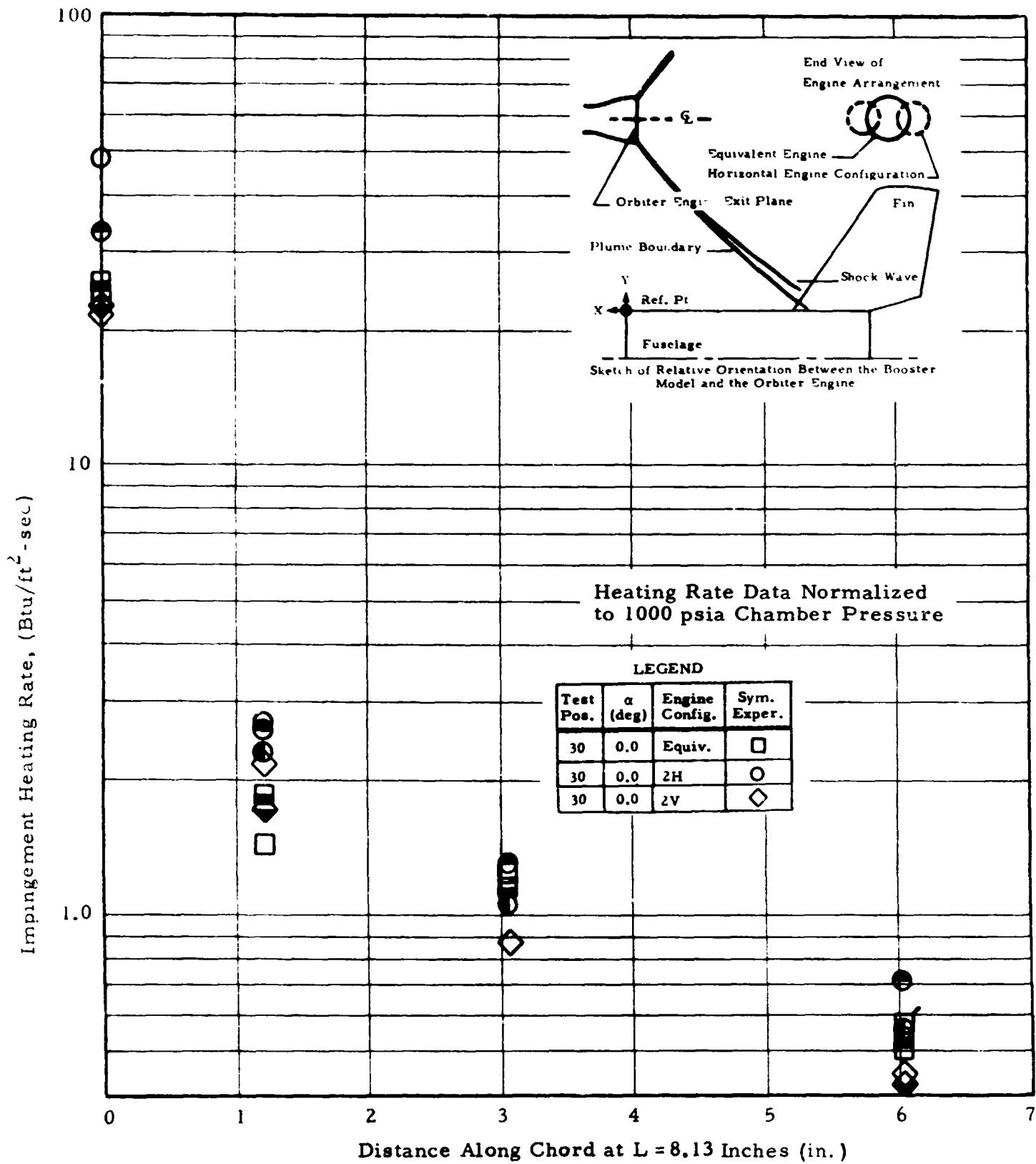


Fig. 116 - Heat Transfer Distribution Along Dorsal Fin Chord + Pos. 30)

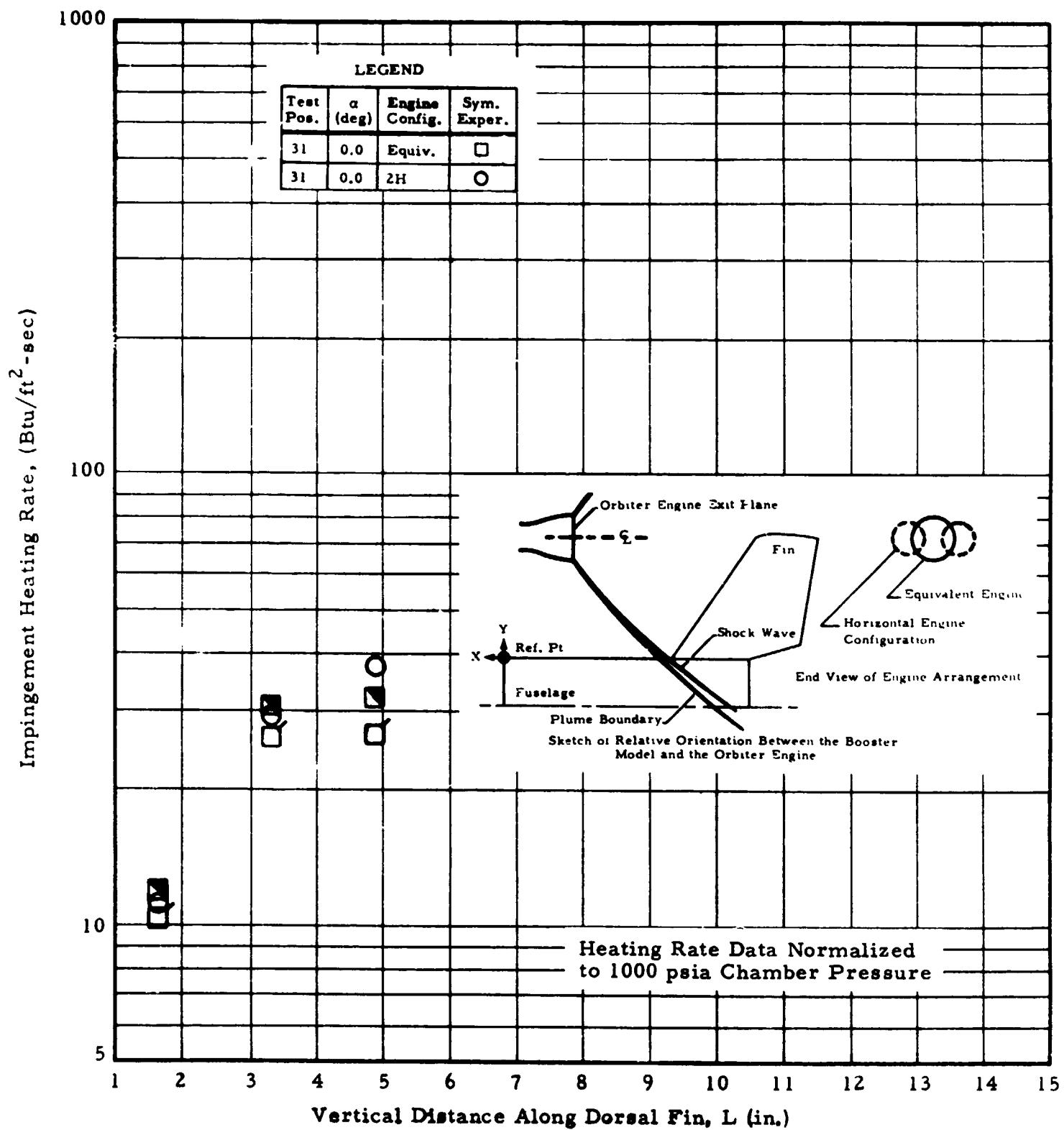


Fig. 117 - Heat Transfer Distribution Along Dorsal Fin Leading Edge (Test Pos. 31)

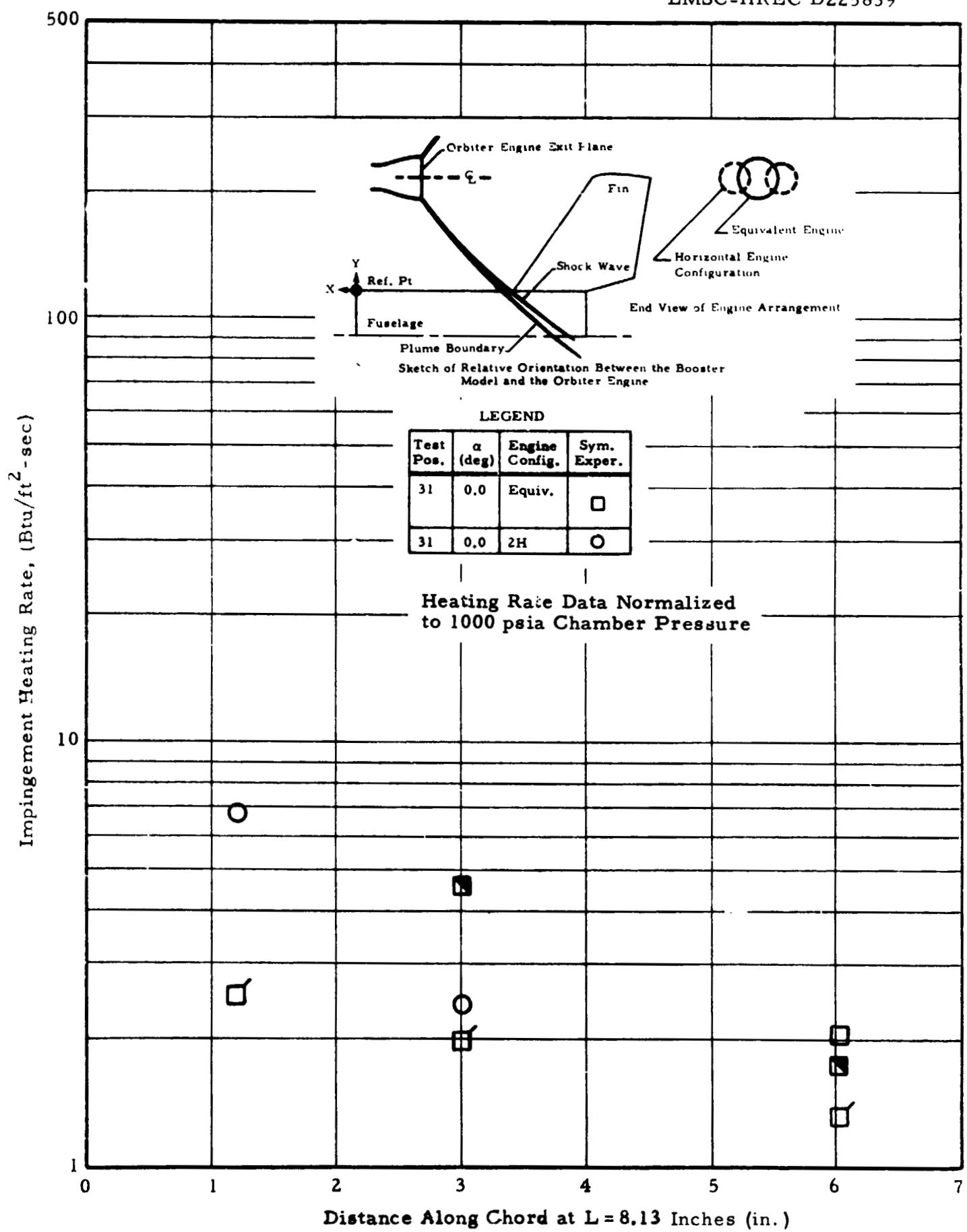


Fig. 118 - Heat Transfer Distribution Along Dorsal Fin Chord (Test Pos. 31)

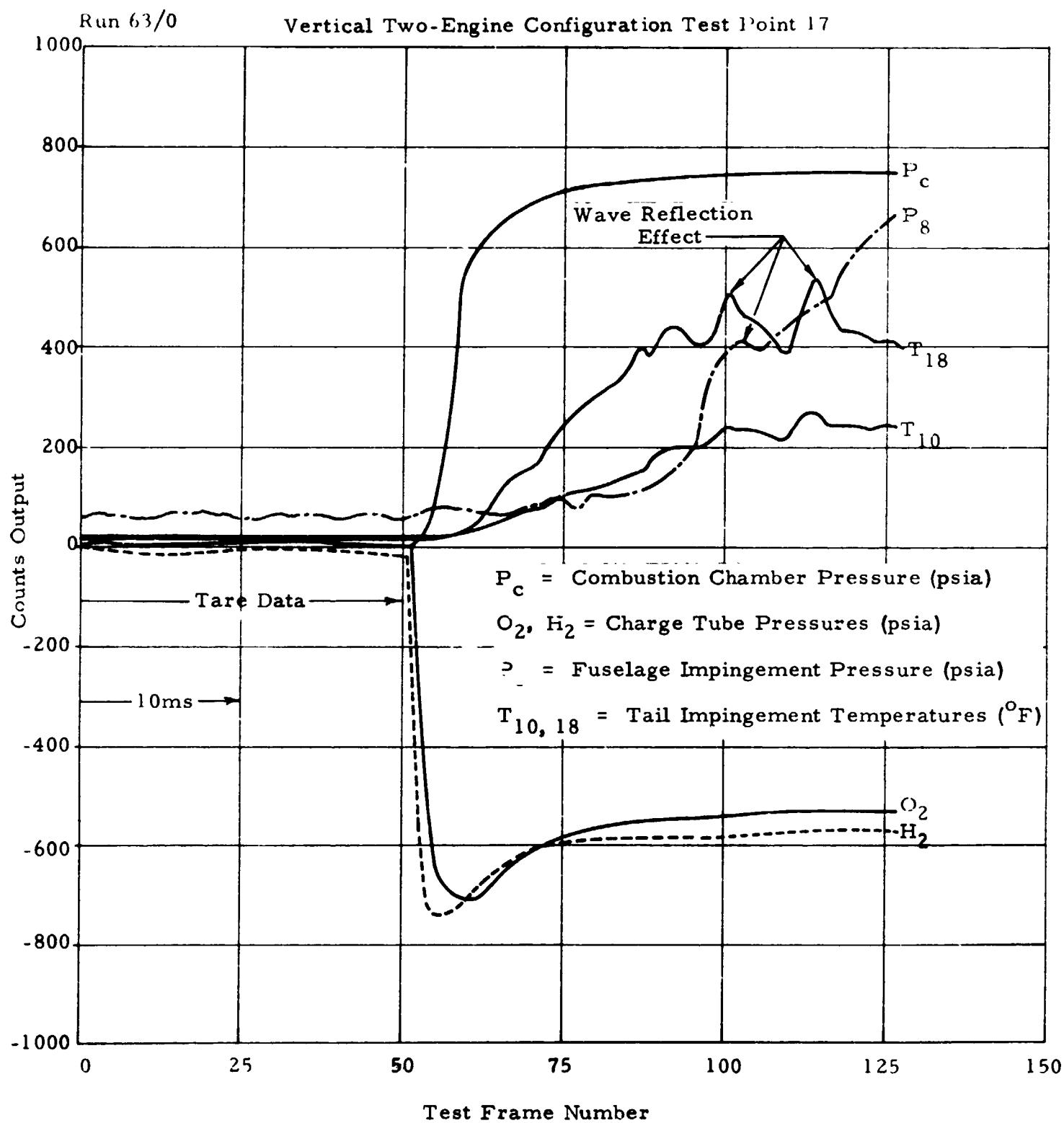


Fig. 119 - Typical Test Data Curves